THE

ELECTRICAL REVIEW.

VOL. XXXIII. SEPTEMBER 1, 1893. No. 823

CONTENTS:

	PAGE
Future Economy in Central Stations	225
The Sources of Electrical Energy	226
The Practical Measurement of Alternating Electric Currents ...	227
An Alternate Current Problem (*illustrated*)	228
World's Fair Electrical Plant	229
High Frequency Currents and "Harmlessness"	231
Arc and Incandescence Lighting	232
Electrical Engineering at the World's Fair.—IX. (*illustrated*)	234
Central Electric Light Stations.—Cambridge Electric Light Supply (*illustrated*)	236
Electrocution	239
Correspondence:—Electrical Engineering at the World's Fair	239
Running Arc Lamps (*illustrated*)	240
Obituary	240
Notes	240
Contracts Open and Closed	243
Business Notices, &c.	243
City Notes:—The Brush Electrical and Engineering Company	245
Traffic Receipts	246
Share List of Electrical Companies	247
On the Transmission of Electric Signals through Space (*illustrated*) (*concluded*)	248
The Oconto Incandescent Lamp Case.—II.	250
New Patents	251
Abstracts of Published Specifications	252

J. A. BERLY'S

UNIVERSAL ELECTRICAL DIRECTORY

For 1893.

ORDER AT ONCE.

PRICE 4/- POST FREE. The **Leading Electrical Trades Directory** *and the Oldest Electrical Directory in the World.*

ONLY A FEW COPIES REMAIN IN STOCK. WE SHALL NOT REPRINT THIS ISSUE.

PRICE 4/- POST FREE. **Fully Revised and Thoroughly Reliable.** *Contains a larger amount of commercial Trade Matter than any other Electrical Directory.*

H. ALABASTER, GATEHOUSE & CO.,
22, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.

Published every FRIDAY, Price 4d.

The Oldest Weekly Electrical Paper. Established 1872.

TO BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address "AGREKAY, LONDON." Code A B C. Telephone No. 517.

ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.

The "Electrical Review" is the recognised medium of the Electrical Trades.

SUBSCRIPTION RATES.—In *Great Britain*, Post Free, per Year, 19s. 6d. To all *Foreign Countries* (except those mentioned below), per Year, £1 1s. 8d. *Exceptions.*—Abyssinia, Aden, Borneo, Ceylon, India, Java, Labuan, Mosambique, Penang, Persia (*viâ* Brindisi), Phillipine Islands, Singapore, Zanzibar, to which the rates are: per Year, £1 8s. 10d.

BINDING.—Subscribers' numbers bound, including case, for 2s. 6d. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

READING CASES, to hold from One to Twenty-six Numbers until the Volume is complete for Binding, can now be had from the Publishers, Price 6s., or Free by Post (in Great Britain), 6s. 6d.

FOREIGN AGENTS.—*New York:* D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 22, Rue de la Banque. *Berlin:* ASHER & Co., 5, Unter den Linden.

Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 22, Paternoster Row E.C.

FUTURE ECONOMY IN CENTRAL STATIONS.

In the near future there will be, no doubt, many anxious considerations as to improving the earnings of unprofitable central stations. It would be mere blindness to imagine that we are going to increase the number of central stations without some of them resulting in dead loss to the proprietors. We grant that it savours of pessimism to suggest such a thing, but we do not think electric light stations will have an immunity from the troubles which affect all commercial enterprise. One would not have to seek far even now to discover a central station, the managers of which were struggling almost hopelessly to improve their revenue. It is quite in the nature of mundane things that electric light stations should occasionally be uneconomical in their working; it may be that they have been designed without much regard to the conditions in which they exist. Our remarks will apply more to provincial undertakings than to those in London. The peculiar conditions of life in the metropolis should render an electric light concern a fair return on its business, even though present systems of supply were not much improved. We have often pointed out in these columns that instead of endeavouring to increase the efficiency of the electrical machinery, probably at a heavy price, greater attention should be paid to the purely steam producing and auxiliary plant. It is not to be thought for a moment that such considerations are not deemed of primary importance in our large systems of supply, but there are many small concerns running at the present time in which very loose ideas of economical working prevail. Where coal and labour is cheap there is great temptation to neglect the golden precepts of economy. Mr. Vail, in a recent issue of the New York *Electrical Engineer*, makes some valuable suggestions as to improving the earnings of unprofitable central stations. Instead of allowing the boilers to stand idle all day, save, perhaps, for the running of a few motors, he suggests that a heating system, if properly carried out, would give considerable additional revenue during the winter months. The author fully recognises the difficulties in the way of supplying exhaust steam for heating purposes, for it is within his knowledge that an electric light station, which was supposed to be earning a good dividend from supplying exhaust steam, had enormous coal bills; on investigation it was found that the steam-heating system was causing a back pressure on the engines of 10 lbs. per square inch. As a result, extra fuel was required to overcome the back pressure of the heating system. But he details a hot water heating arrangement which would obviate the difficulties met in the steam heating. The exhaust steam is taken to a suitable place and utilised in raising water to a great heat, the surplus steam being discharged into the air. In the summer he suggests that the manufacture of ice and cold storage be carried out. While these applica-

tions would be quite feasible in America, we doubt whether they would be possible in England. In spite of the advance of education, the dear old English fireplace will live for many a day to come; pipes for heating purposes are utterly opposed to our insular notions of comfort, and the demand for cold storage is only occasionally felt, such as in the present summer season. Although these suggestions of Mr. Vail's would be impracticable in England, they should be sufficient to set English central station engineers thinking of possible outlets for the heat units that could be generated during the 24 hours, and thus improve the earning capacity of the steam plant.

THE SOURCES OF ELECTRICAL ENERGY.

MR. FRANCIS B. CROCKER is contributing a series of articles to the N.Y. *Electrical Engineer*, which is to form a study of the various sources of electrical energy. It is a little vague, perhaps, to speak of the "source" of any form of energy, all questions of this kind resolving themselves into a contemplation of the interdependence and transformation of the various manifestations of energy, the actual "source" being a thing apart—the present meaning is, however, now fairly established. These articles are pre-publications of a forthcoming treatise on Electric Lighting by Mr. Crocker; they are written in great simplicity of style, and should be very useful as an introduction to the subject by beginners. The steam engine is discussed upon an easy theoretical basis, as a fundamental problem in thermo-dynamics, giving the equation for efficiency, and showing how to calculate the rate of consumption of coal. Reasons are also given for working at comparatively high pressures. The gas engine is shown to possess great apparent advantages over the steam engine, for the reason that the high pressure and temperature are produced directly in the cylinder, which can be made of almost unlimited thickness, since it is comparatively small, and the heat does not have to be transmitted through its walls. The hot-air engine, though safe and convenient, is regarded as far inferior to the internal combustion gas engine, in actual, as well as theoretical, efficiency and output. The idea of substituting other fluids for water is shown to be fallacious, both scientifically and practically. The generation of electric currents by thermo-electric batteries is put in a very fair light. Mr. Crocker has made numerous experiments in connection with these batteries, and has seen some of them which have been in use for several months, almost continuously, giving a fair output of ·05 volts *external* P.D., and 5 ampères, per element, without any apparent diminution in activity. There seems to be a great difficulty in securing a suitable joint between the dissimilar metals. The best results so far obtained do not give an efficiency of more than 1 or 2 per cent.; that is, not more than 1 or 2 per cent. of the heat energy is converted into electrical energy. The directness of the process is said to make up for a considerable sacrifice in efficiency.

The thermo-magnetic or pyro-magnetic generator, depending upon the fact that iron or nickel lose almost all their power to conduct magnetism when heated to a certain temperature, is one of the latest devices for the transformation of energy. A core of iron surrounded by a coil is connected to a magnet by means of thin strips of iron or nickel, the strips being alternately heated and cooled, which cuts-off, or puts-in, lines of force through the coil. This machine has the same disadvantage as the thermo-electric battery, being low in efficiency, and requiring a large apparatus for a comparatively small output. Nickel has usually been employed instead of iron as the material to be alternately heated and cooled, for the reason that it loses its magnetic conductivity at a lower temperature than iron, this point being 310° C., but nickel having lower permeability than iron, the amount of magnetism is also less. Theoretically it might be better to employ iron instead of nickel, since its point of practical demagnetisation is 785° C., and the second law of thermo-dynamics applies here as to all apparatus for converting energy from heat to any other form.

A New Induction Balance.

ALTHOUGH the "Hughes" induction balance is an instrument which exhibits great sensitiveness, it has not come into use in the measurement of specific resistance because absolute measurements cannot be made with sufficient accuracy by means of it. Oberbeck and Bergman have recognised this failing, and by dint of ingenuity, have made the instrument fairly trustworthy in the measurement of the specific resistance of very thin plates of metal; but this system presents some obvious disadvantages. In the *Annalen der Physik und Chemie*, No. 6, 1893, pp. 306—346, there is an exhaustive paper in which the behaviour of this instrument is criticised by M. Wien. He goes on to show how, by adopting a new form of induction balance, which he describes with illustrations, measurements of the specific resistance of metals can be effected without resorting to a comparison with a standard metal; in other words, how absolute measurements can be made. The special features in Wien's method are: (1) that the operator is independent of faults of contact and thermal effects at contact; (2) that the measurements are made on metals in their normal state before they are influenced and their structure modified by wire-drawing; (3) the specific resistance can be measured without determining a length.

Substitutes for Ampère's "Swimmer."

IN a recent issue of *Nature*, Prof. Alfred Daniell expressed his dissatisfaction with the rules commonly given in order to enable the relation between the direction of a current and that assumed by a magnet in its neighbourhood to be mentally pictured. The vagaries of Ampère's "swimmer" are "past the wit of man." Prof. Jamieson's rule, though possessing advantages, is not really easy to remember; the corkscrew is good, provided that one has a little time to think about it. Prof. Daniell suggests the following as a useful substitute for the "swimmer" notion. If a penholder be held in the right hand in the usual way, it may be taken to represent the wire, and the direction of the flow of ink (that is towards the point of the nib), the direction of the current; if then, the thumb be stretched a little across the penholder it will represent the magnet and the thumb-nail its marked or north-seeking pole. The hand may, of course, be twisted round into any position to represent any actual case. The same relation may be still more simply borne in mind by dispensing with the penholder and merely laying the thumb across the forefinger of the right hand; either of these will then represent the current (flowing towards the finger or the thumb-nail, as the case may be), the other the magnet. In Denmark it is pointed out by a correspondent to *Nature*, of August 17th, that the following simple rule given by Prof. Holten is used. The outstretched right hand is put in the current with the palm turned toward the magnet and the fingers in the direction of the current. Then the north-seeking pole will be moved in the direction of the thumb.

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.

PROF. J. A. FLEMING, M.A., D.Sc., F.R.S., delivered the first of his Cantor lectures upon the practical measurement of alternating electric currents before the Society of Arts, January 30th, 1893. The lecturer, in introducing his subject, pointed out that by far the larger portion of the electric lighting of the world is now effected by alternating currents, and that some of the largest schemes of transmission of power that are in process of development, or already completed, are being carried out by means of such currents. He confessed that nothing was known about the real nature of an electric current; all that could be done was to measure the degree or amount of the physical effects it produced. Two of these effects were evident on very simple investigation, *i.e.* (1) That the current heats the conductor; and (2) That it produces around it a magnetic field. The moment these effects are investigated, it is found that the electric current may be either in a variable state, in which progressive changes are taking place in the effects produced by the current, or it may be a steady, or unvarying, condition, in which the effects remain constant; or again, it may give evidence of being periodic in its nature, that is to say, the electric current may vary in strength and in direction, in a periodic manner. When any cycle of operations takes place in such a way that any given effect runs through a series of changes, we speak of the "periodic time" of that effect; meaning the time in which the whole cycle of operations is completed. Also we speak of the "frequency" of the change; meaning by that term, the number of cycles completed in a second. In the case of electric currents which are periodic, the strength is changing from instant to instant, and it is periodically reversed in direction. Applying the above terms to the electrical case, "the *frequency* of the current" is spoken of; meaning the number of complete cycles of the current in a second. For instance, the alternating current supplied from Deptford had a frequency of about 84; the currents employed in the electric lighting of Rome have a frequency of 40.

If a horizontal line is taken to represent the periodic time of a current, and, dividing this line into a number of small equal parts, we erect perpendiculars at each point, proportional to the strength of the current, or to the electromotive force at that instant; then, by joining the tops of these lines, we have at once an electromotive force, or current, curve. We may then speak of the "instantaneous" value of the current or E.M.F., meaning thereby the value it has at any instant; or we might refer to the "mean" value of the current or E.M.F., which is the average value during the period. A rather more complicated kind of average was "the square-root of the mean-square" value. This is obtained by taking the mean of the squares of all the instantaneous values at the equi-distant intervals during the period, and then calculating the square-root of this mean value. To avoid constant repetition of this cumbersome phrase it might be referred to shortly as the $\sqrt{\text{mean-square}}$ value of the current or E.M.F. Certain instruments give this $\sqrt{\text{mean-square}}$ value by direct indication.

It was important, sometimes, to be able to draw these current curves for any alternating current, as has been done notably by Duncan, Ryan, and Hopkinson. The apparatus of Hopkinson consists of an ebonite disc, having, at one point of its circumference, a narrow feather of brass; this disc is fitted to the shaft of an alternator, and, as it is carried round by the machine, the brass edge is made to complete the circuit between two metallic brushes, which press against the ebonite disc, and the instant that this occurs can be determined by varying the position of the brushes. By connecting an electrometer to the brushes, the instantaneous value of the E.M.F. of the machine, at any instant, may be determined. By shifting the position of the brushes it was possible to measure the E.M.F. at equi-distant intervals during the period, and from this to plot out the E.M.F. curve. In the same way, by measuring the instantaneous values of the potential difference between the ends of the resistance traversed by an alternating current, the form of the current curve for that particular current could be delineated.

Dr. Fleming then observed that it was not the instantaneous values which were of so much importance in electric measurement, nor is it the true mean value of an alternating current which is practically required. In by far the larger number of cases the only thing that has to be known, and the only thing which can be measured, is the $\sqrt{\text{mean square}}$ value, as explained above. The rate of production of heat in an electric circuit was at any instant proportional to the square of the current strength; hence, if the current strength is changing from instant to instant, the total quantity of heat produced in the wire in any given time is proportional to the mean of the square of the current strength. Under fixed conditions, the temperature which the wire will assume will depend upon this mean square value of the current; for the wire attains its final temperature when there is a balance between the rate at which the heat is generated in it, and the rate at which the heat is lost by it. The wire loses heat in three ways—by convection, by radiation, and by conduction. If a wire is enclosed in a tube so that convection is prevented, then the wire attains a final state of temperature when there is a balance between the rate at which the wire loses heat by radiation, and gains it by internal generation. Under these conditions, the temperature, and therefore the length of the wire, is determined not by the average, but by the mean square of the current strength. If, therefore, the current is alternating, the final temperature, and therefore the length of the wire, enables us to measure this mean square value of the current. In the same way, if two conductors, one of which is fixed and the other movable, are traversed by the same electric current, the electro-dynamic repulsion or attraction between these two conductors, due to the magnetic field around them, becomes a measure of the same mean square value of the current; for at any instant the stress between the conductors is proportional to the square of the current strength flowing through them; and if the current is varying from moment to moment, the average value of this stress is a measure of the mean of the square of the current strength. Either of these two physical effects might therefore be employed to measure the mean square value of the current, *i.e.*, the heating of a wire by a current, or the mutual stress between two conductors traversed by the same current. The alternating current of 1 ampère was understood to mean a periodic current which, when passed through a conductor, brings this conductor to the same final steady temperature as an unvarying current of 1 ampère would do if passed through it under the same conditions. It is, therefore, an alternating current whose $\sqrt{\text{mean-square}}$ is unity, assuming the instantaneous values to be measured in fractions or multiples of an ampère.

The lecturer, in describing the various forms of the electro-dynamometer, pointed out that if a copper plate is held in front of an alternating electro-magnet it is repelled; and, similarly, if a copper plate is placed near the movable coil of a dynamometer, it repels the coil when that coil is traversed by an alternating current. If the disc is so placed that in its normal position its plane is inclined at an angle 45° to the axis of the coil (assumed fixed), the copper disc turns round so as to place its plane in the direction of the axis of the coil, when an alternating current is sent through the coil. In an instrument of this kind, designed by the lecturer many years ago, the turning is resisted by the torsion of a wire, and the current is calculated from the angle of torsion. Such an instrument can be made to measure alternating currents as small as one thousandth of an ampère. The law of this instrument, as recently determined by Dr. Fleming, is simply that the angular displacement of the disc from its position of equilibrium is closely proportional to the square of the current strength passing through it.

A small coil was placed in a horizontal position in front of an optical lantern, and a small fragment of iron was suspended in the centre of the coil. On the screen was observed the shadow of the coil and the iron. On passing an alternating current through the coil, the piece of iron was seen to be drawn away from the centre of the bobbin, and to move against the side; the explanation being that a piece of soft iron, when placed in a varying magnetic field, tends to move from places of weak to others of stronger magnetic force; and, other things being equal, the force so displacing the iron, at any point, is proportional to the product of the strength of the field, and the rate of change of that field at that point. This fact can be shown in another way: if a sheet of glass is placed horizontally over the top of the coil, held vertically, and sprinkled with iron filings, they move out

from the centre of the bobbin towards the edge, the reason being that the magnetic field of the bobbin is weaker at the centre than it is close up against the wire. This principle is employed in the construction of a large number of instruments. In that of Prof. Elihu Thomson a small plate of soft iron is attached to an axis which passes through the centre of a bobbin, in such a manner that if the iron is displaced from the centre to the edge of the bobbin that movement is indicated by the needle. Hence, when an alternating current is passed through the coil, forces are brought to bear on the iron, tending to displace it from the centre to the edge of the coil. A weight is so arranged as to resist this movement, and the instrument may be calibrated for different current strengths, and constitutes what is called the gravity instrument, because no springs are used in its construction. In the similar instrument of Von Dobrowolsky there is a coil of wire within which is suspended a very slender fragment of iron wire. When an alternating current is passed through the coil, the iron is drawn down into the coil, owing to the tendency it has to move from weak to strong places in the field. This movement is resisted by the gravity of a small weight. A needle attached to the axis which carries the fragment of iron wire moves over a graduated scale, and the instrument can be graduated as an alternating current ammeter. Other instruments upon the same principle were also described. In the ammeter of Evershed a compensation is provided, to allow for the fact that the forces acting upon the iron depend to some extent upon the frequency of alternation. The working coil is shunted by an inductive shunt, which takes about 6 per cent. of the total current as direct currents, but only about 2 per cent. as alternating currents. The result is, that the working coil takes about 2 or 3 per cent. more current with alternating currents, and eliminates any error due to eddy currents set up in the bobbin, frame, and case.

Another instrument was described which could be employed for such small currents as those produced by a telephone. There is a fixed coil of wire, at the centre of which is suspended a very small fragment of iron wire, with its axis inclined at an angle of 45° to the plane of the coil. The wire hangs by a cocoon fibre, and, by means of a fragment of mirror attached to the iron, its smallest movements can be detected. When an alternating current traverses the coil, the iron wire tends to turn so as to place its greatest length in the direction of the field of the coil. It is possible, by a similar arrangement, to measure the millionth part of an ampère. It is necessary, when accurate instruments such as the Kelvin ampère-balance are employed to measure alternating currents, to avoid bringing any metal piece into contiguity with the coils. The base should therefore be of slate or similar material, and the bobbins should also be of a non-metallic substance.

Another class of instruments for measuring alternate currents were those which depend for their action upon the heating of a conductor through which the current passes. The first of these, described by the lecturer, was the twisted strip ammeter of Profs. Ayrton & Perry. In this instrument a strip of platinoid is stretched between two supports and twisted in the middle, so that the two halves of the strip form right and left handed spirals. When this is done, and the strip fixed at its two extremities, if an electric current is passed through it, and heats it, the strip twists up more. If an index needle is attached to the middle of the strip, then the passage of a current through the strip may be made to cause this needle to move over a scale, and the position of the needle at any instant indicates the strength of current. When the strip is enclosed in a tube made one-third of iron and two-thirds of brass, the ends of the strip being attached to the ends of the tube by an insulating support, then no variation of the temperature of the tube and strip, as a whole, will affect the length of the strip, and hence such an arrangement will constitute a compensation for external temperature. If, however, the strip be supposed to be cooled or heated apart from the tube, it will untwist or twist-up more. In order to be able to observe the movements of the strip relatively to the tube, a slit has to be cut in the side of the tube through which the needle attached to the strip can project. In the real instrument the tube containing the strip is fixed to a stout bracket which divides it into two parts, the compound tube having the same coefficient of expansion as platinoid. A needle attached to the centre of the strip projects through a cut in the tube, and moves over a divided scale. If a current is sent through the strip it takes up a certain definite temperature, and there is a balance between the rate at which heat is generated in the strip, and the rate at which it is radiated to the inner walls of the tube. Accordingly there is a definite position of the needle corresponding to any particular mean-square value of the strength of the current, and by passing steady currents through the instrument it can be calibrated for use with alternating currents. Such an ampèremeter can be made to read from about ·2 to 5 ampères, reading by hundredths of an ampère. For the ready measurement of small currents the instrument is convenient, but there are certain difficulties connected with its use, which are common to all such thermal instruments. The hot-strip ammeter of Captain Holden was next described; in this instrument there are two strips fastened together into a compound bar, as in the classic thermostat. The distortion of the compound strip is made to actuate a needle through a system of levers.

The extremely ingenious device of the late W. G. Gregory might here be included amongst the twisted-strip instruments. By the use of a very sensitive twisted-strip he in part succeeded in obtaining quantitative measurements of electrical radiations. His death occurred before he was able to complete the experiments; they were described in a paper read by him before the Physical Society, November 1st, 1889.

AN ALTERNATE CURRENT PROBLEM.*

BY W. D. WEAVER.

IN one of E. Arnold's articles in the *Electrical World* the statement is made that if the current of one of two alternators rigidly coupled is used to excite the field of the other one, the E.M.F. of the second alternator will have twice the periodicity of that of the first.

To investigate this, assume that the first alternator, A, has its field excited by a continuous current, and that the resulting alternating current follows the sine law. To simplify the case, let fig. 1 represent the equivalent in action of two poles of an alternator, and consider both alternating circuits free from any action that would distort or lag either curve of E.M.F., and further assume that the field of B will vary in strength directly with the exciting current.

In fig. 1 the open circle on the circumference of the armature represents a coil on alternator, A, and the filled circle one on alternator, B; the angle the first coil has

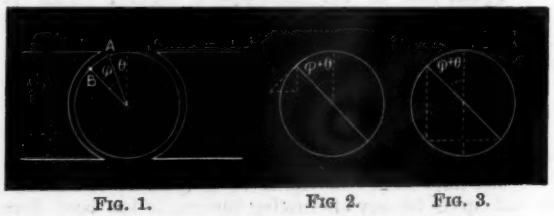


FIG. 1. FIG 2. FIG. 3.

advanced beyond its neutral position is denoted by θ and the angle between corresponding coils on the armatures by ϕ.

As the field of alternator, B, is due to an alternating current, its coil will have two E.M.F's induced in it, one due to its cutting lines of a force as a dynamo coil, and another from the varying field causing it to act as a transformer coil, and the efficient E.M.F. will be the resultant of these two.

First, consider the dynamo induction, which will be the product of the field, H, by the rate, $d\,v$, at which the lines of force are cut, or $H\,d\,v$, neglecting the various dimensions, as the result desired is merely comparative. Assuming the current supplied by the alternator, A, to the field of, B, to vary according to the law $i = \sin\theta$, the strength of the field at any instant is $\sin\theta$; referring to fig. 2 it will be seen that the rate of cutting, $d\,v$, is $\sin(\phi + \theta)\,d\,\theta$, so that we have finally for the dynamo induction at any instant the value

* The New York *Electrical World*.

$$d\,e_d = \sin\theta \sin(\phi + \theta)\, d\,\theta$$

and the total dynamo E.M.F. at that instant is

$$E_d = \int d\,e_d = -\frac{\sin\theta}{2}\cos(\phi + \theta) \qquad (1)$$

Next, consider the transformer induction, which will be the product of the opening of the coil any instant by the variation of the flux at that instant. The variation of flux will be $d\,i = \cos\theta\, d\,\theta$, and, referring to fig. 3, it will be seen that the opening of the coil is $\cos(\phi + \theta)$. The transformer induction, therefore, at any instant has the value

$$d\,e_t = \cos\theta\cos(\phi + \theta)\, d\,\theta$$

and the total transformer induction at that instant is

$$E_t = \int d\,e_t = \frac{\sin\theta}{2}\cos(\phi + \theta) \qquad (2)$$

The difference between (2) and (1) is the efficient E.M.F. $= \sin\theta\cos(\phi + \theta)$.

Curves of E.M.F., from this formula for different values of ϕ as given, are plotted in full lines in fig. 4; the dotted curve

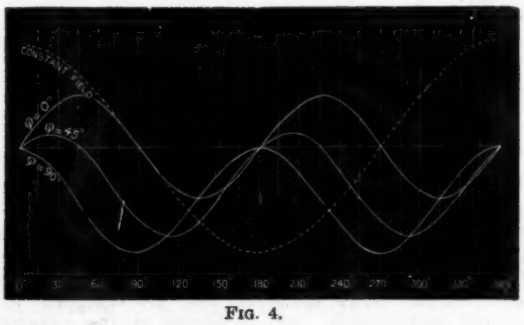


FIG. 4.

shows what the curve of E.M.F. would be if the field were constant. As will be seen, the curves when ϕ is 0 degree or 90 degrees are symmetrical and have twice the periodicity of the dotted curve; for values of ϕ between 0 degree and 90 degrees the curve is not symmetrical, and becomes less and less so as ϕ approaches 90 degrees in value. For higher values of θ the curves of the first two quadrants are duplicated.

WORLD'S FAIR ELECTRICAL PLANT.*

BY R. H. PIERCE.

OF all the cities that have ever been built, there has never been one in which electricity has played such an important *rôle* as in the White City.

The present exposition is the first international exposition in which electricity has been recognised as one of the great departments, and no previous electrical exhibition has equalled the electrical exhibit of the World's Columbian Exposition.

Volumes have already been written upon the various electrical exhibits, and all that will be attempted in this brief paper is a description of the great plant which furnishes the electrical service of the exposition.

The electrical plant comprises a local telephone exchange, complete systems of police signal and fire alarm service, and the plant for furnishing electric power and light.

TELEPHONES.

The telephone exchange is a regular exchange of the Bell system. It comprises at present 130 telephones. It supplies service for the offices of the officials, the engineers and superintendents. It forms an adjunct to the fire alarm service, and connects the headquarters of the police department, the department of admissions, and of the secret service with all gates and with all portions of the grounds. It contains no points of novelty, but is an interesting exhibit of a great private exchange. It is installed with complete metallic circuits of double and twisted rubber covered conductors. The circuits comprise 150 miles of No. 18 B. and S. wire, and the service is practically unaffected by the proximity of the immense number of circuits carrying currents, both direct and alternating, and all degrees of current strength.

* Read before the World's Congress of Architects, Chicago, August 2nd, 1893.

POLICE AND FIRE SIGNALS.

The police signal and fire alarm systems comprise 137 fire alarm boxes of the Gamewell Fire Alarm Telegraph Company, and 137 police boxes, and 50 watchmen's patrol boxes of the Police Telephone and Signal Company.

These systems are too well known to need even comment, and make the service uniform with that of the City of Chicago, to which it is connected.

The boxes are distributed about the grounds and buildings in pairs, each fire alarm box having a corresponding police box. The number of boxes is estimated to be sufficient for protecting a city of 150,000 inhabitants, and its installation consumed 80 miles of No. 14 B. and S. rubber covered wires.

The watchmen's patrol boxes are located under the floors of the main buildings and enable the guard to send in an alarm direct to headquarters, without even the loss of time required to reach the nearest fire or patrol box.

LIGHT AND POWER PLANT.

The portion of the plant which especially commends itself to the interest of both the engineer and the architect is the plant for electric lighting and electrical transmission of power.

All the electrical machinery for furnishing light and power is located in machinery hall, so that the power plant in machinery hall is a great central station. I say "central station," but in fact the plant is divided, as far as operation is concerned, into nine distinct central stations, each of which, under normal working conditions, is entirely independent.

The plant comprises 98 direct current series arc dynamos, having a total capacity of 5,230 lamps of 2,000 nominal candle power each, 14 alternating current incandescent dynamos, having a total capacity of 128,000 lamps of 16 candle power, one direct current incandescent dynamo having a total capacity of 800 kilowatts and 20 direct current power generators, having a combined capacity of 2,936 kilowatts or 3,935 electrical horse-power. In addition to these, there are also four direct current generators, having a total capacity of 600 kilowatts or 804 electrical horse-power, which serve the double purpose of supplying current to operate the electric fountains and to charge the storage batteries for the electric launches. There are also one direct current generator of 700 kilowatts or 938 electrical horse-power, which operates both arc and incandescent lamps; and, finally, one direct current generator of 180 kilowatts, and one of 45 kilowatts, a total of 225 kilowatts, or 300 electric horse-power, which supply the current for search lights. The entire plant has a generating capacity of 14,916 kilowatts or 19,989 electrical horse-power, so that it would require not less than 25,000 indicated horse-power to operate all the dynamos to their full working load.

CIRCUITS.

The circuits from all dynamos are carried under the floors of the power plant to the several switchboards, and thence under the floor to the gallery, which runs the entire length of the power plant, and under the aisle directly north of the plant. This gallery is for the greater part of its length, 13 feet wide and 9 feet high, and is shut off from the rest of the basement on both sides by walls of expanded metal and cement. Along each side of the gallery is a row, and down through the centre are two rows of cast-iron uprights placed 30 feet apart. These uprights have sockets into which are driven oak cross arms. These arms carry from four to six pins, and have, in all, sufficient pins and insulators for 280 wires, allowing but one wire to an insulator, but, by the use of a special two-wire insulator designed for this purpose, the capacity of the gallery is greatly increased.

From this gallery, the circuits are carried out of machinery hall in the main subway and the duct trunk line. All the circuits feeding the east portion of the park are carried in an underground tunnel called the main subway.

SUBWAY.

The main subway, as it passes under the east end of machinery hall going north, is a double tunnel, each half of which is constructed as follows: A series of frames are built of 3 inch by 8 inch timber, and are covered on the outside, on the top and sides, with 2-inch plank. On the inside, the top and sides are covered with expanded metal and plaster, and the floor is formed of Portland cement. This forms a practically fireproof tunnel, 6 feet 6 inches wide and 6 feet 5 inches high. To the timbers on both sides of each tunnel are lagged cast-iron uprights 30 feet apart. These uprights carry on each side of the subway 12 five-pin cross-arms 2 feet 3 inches long, so that one can walk in a 2-foot passage having on either side a regular underground pole line. Conductors are carried on double petticoat insulators, there being capacity in the entire subway for 240 insulators. Here, as in the gallery, many two-wire insulators are used. The subway is lighted by incandescent lamps and drained by hand pumps located at low points. Where single insulators are used, all wires are rigidly separated and not less than 5 inches of air space is allowed.

The main subway runs due north to electricity building, where the west half enters the building, and then branches, running to the mines building, and the east half makes a right angled turn, running east to the bridge over the north canal. The circuits are then carried under the bridge, and on the east of the bridge the subway is continued to the southwest corner of manufactures building, whence, decreased in section, it runs north the entire length of the manufactures building, under the west loggia. It then runs east to a point north of the centre of the manufactures building, thence north to the government building. Under the government building it is constructed with a covering of expanded metal and plaster, both inside and out, and from the government building it is continued to the fisheries building, where it ends.

DUCT TRUNK LINE.

The circuits feeding the west half of the Park and Midway Plaisance, with the exception of the power circuits, are carried from the gallery under machinery hall to the north side of machinery hall in a conduit of 3 and 4-inch vitrified tile ducts. Thence the duct trunk line is continued by 30 ducts of pump log of 2¼-inch bore. Large manhole boxes, 30 inches by 36 inches, are set every 150 feet. This trunk line runs under the terminal tracks to the southwest corner of transportation annex, whence it runs parallel to the fence, to a point near the north end of the California state building.

From the main subway and duct trunk line, the circuits are distributed throughout the grounds in wooden ducts of 2¼ inch bore. These ducts form a network all over the park, and are intersected at angles and convenient points by manholes with cast-iron covers. There are in all about 100 miles of these ducts, and about 3,500 manholes.

Thus all circuits are carried underground except those south of machinery hall and along fences. These are carried on poles, while the power and telephone circuits on the west side of the park are run under the structure of the elevated intramural railway.

Having indicated the general arrangement, I will describe as briefly as possible the plant, taking up the different kinds of service in order.

For the purpose of description, we will divide all the dynamo-electric machines into two classes. First, exposition dynamos, or machines furnishing service to the exposition and operated by the electrical engineering department; secondly, exhibit dynamos, or machines furnishing current to exhibitors in electricity building and operated by the various electrical companies which furnish them as exhibits.

The arc light plant comprises the following machines.

Western Electric Plant:	10 Exposition dynamos,	50 lts. each, total,	500	lights.
	2 Exhibit „	50 lts. each, total,	100	„
Thomson-Houston Plant:	27 Exposition dynamos,	50 lts. each, total,	1,350	„
Excelsior Plant:	6 Exposition dynamos,	50 lts. each, total,	300	„
Standard Plant:	22 Exposition dynamos,	50 lts. each, total,	1,100	„
Fort Wayne Plant:	13 Exposition dynamos,	60 lts. each, total,	780	„
	1 Exhibit „	60 lts.	140	„
	1 „ „	80 lts.		
Brush Plant:	12 Exposition dynamos,	60 lts. each, total,	720	„
	4 Exhibit „	60 lts. each, total,	240	„

There are, therefore, 90 exposition dynamos, having a total capacity of 4,750 lights, and seven exhibit dynamos, having a total capacity of 480 lights, or a grand total of 99 dynamos, having a total capacity of producing 5,230 lights, all of 2,000 nominal candle-power. All these dynamos are regular direct current series machines, and are equipped with standard switchboards and appliances of the respective systems.

In addition to the foregoing, there are, in the terminal station, 160 six ampère arc lamps, and 228 three ampère lamps, equivalent to 164 lamps of 2,000 nominal candle power. There are also 351 Helios arc lamps attached to the incandescent circuits, most of these furnishing lights to exhibitors and to the concessionaires in the Midway Plaisance.

The grounds are lighted by 1,421 lamps, of which 1,308 are upon ornamental iron lamp posts, and the remainder, which light the fences and the south grounds, upon 40-foot wooden poles.

The grand total of all arc lamps in the plant at the present time is equivalent to 5,362 lamps of 2,000 nominal candle-power. The outside circuits are all carried underground, excepting those south of machinery hall and along the fences.

DISTRIBUTION OF ARC LIGHTING.

BUILDING.	MAIN FLOOR.			GALLERY.			Total lights inside.	Average sq. ft. per light.	Loggia and court lights.	Total number lights.	REMARKS.
	No. Lights.	Sq. ft. per light.	Distance apart.	No. Lights.	Sq. ft. per light.	Distance apart.					
Machinery	238	1,497	25	...	...	...	...	...	26	...	...
„ annex	17	1,516	25	...	...	...	411	1,505	Loggia	437	...
Horticultural dome	37	1,113	24	36	856	28	...	...	...	...	...
„ curtains	52	815	25	...	...	...	200	951	17	...	...
„ pavilions	48	1,197	34	27	1,049	30	...	...	Courts	217	...
Anthropological	55	1,886	35	32	1,499	38	87	1,743	...	87	...
Manufactures	389	1,687	30	314	1,828	40	...	...	70	...	...
„ coronas	414	1,048	...	...	...	...	1,117	1,499	Loggia	1,187	...
Agriculture	202	1,826	30	165	1,345	40	...	...	...	...	...
„ annex	81	2,022	50	...	...	...	448	1,684	16 loggia	464	...
Mines	111	1,998	30	64	1,904	40	177	1,964	8	85	...
Fisheries	28	2,132	40	14	1,446	40	49	...	...	...	...
„ W. pavilion	7	1,954	45	...	...	...	...	1,910	...	49	...
Illinois State	33	1,421	25	39	445	40	72	898	6	78	...
Transportation	181	1,346	33	130	1,230	32	311	1,298	6	...	...
„ annex	149	2,445	45	...	...	...	149	2,445	Clère	466	Helios arc
Leather	48	1,470	45	31	1,669	41	79	1,712	...	79	...
Forestry	59	1,483	35	...	...	...	59	1,483	...	59	...
Totals and average for main buildings	...	...	...	...	...	...	3,159	1,544	149	3,308	...
Miscellaneous buildings	...	...	...	...	...	...	...	...	...	18	...
Total lights in buildings	...	...	...	...	...	...	...	...	...	3,426	...
Total inside area	...	...	...	...	...	...	...	...	...	...	4,877,965 sq. ft.

In the duct trunk line and in all underground ducts, the conductors are of No. 8 B.W.G. rubber-covered safety wire, having an insulation of $\frac{1}{8}$th inch para-rubber compound, a part having mechanical protection of lead, and the remainder being protected by two tapes wound in reverse. 90 miles of this wire is used. The circuits in the main subway and in buildings are of No. 8 B.W.G. safety wire, having a covering of 74 mils. thickness of rubber and braided. Of this wire there are about 200 miles.

All arc lamps are furnished with opalescent or opal globes. This, of course, materially reduces the candle power, but by diffusing the light, undoubtedly gives much more uniform and satisfactory lighting than could be obtained by clear or ground globes. The general style of construction in the buildings consists in suspending the lamps from a No. 9 W. & M. iron wire, the conductors being run from lamp to lamp in the air. The lamps are attached to hangers which are insulated both from the lamps and the line. This method of construction has the advantage of using the minimum amount of wire and doing away with all unsightly loops. It is quickly and cheaply put up and presents a neat mechanical appearance. The lamps on posts and over the aisles in buildings are trimmed with step ladders, except in machinery hall, where they are trimmed from travelling cranes. In certain cases, where the lamps are hung in inaccessible places, a special form of hanger is used, so that, by pulling a cord, the lamp can be disconnected from the circuit and dropped to any desired height, and again pulled into place, without interrupting the circuit. The device also does away with the use of any slack wire.

The grounds and all the buildings are supplied with two entirely independent circuits. One set of evening circuits has single carbon lamps, calculated to burn from dark to the closing hours of the night. The other set of circuits, which comprise about 10 per cent. of all the lighting on the grounds, is used for patrol, or all-night lighting.

The feature of the arc lighting is undoubtedly the lighting of the central nave of manufactures building. Here the lights are suspended from five great fixtures or coronas. The space to be lighted is 1,268 feet long and 368 feet wide. The coronas are suspended 140 feet from the floor. The central corona is 75 feet in diameter and carries 102 lamps. The other four coronas, which are equally distributed along the main longitudinal axis of the building, are 60 feet in diameter and carry 78 lights each, making a total of 414 lamps. The coronas, which are made of angle iron, are circular hanging galleries in which the trimmer can walk from lamp to lamp. They are reached by iron ladders from the trusses above. The great arched roof of the building acts as a reflector for the lamps, and the lighting, as it appears to the eye, is absolutely uniform.

SEARCH LIGHTS.

There are at present installed four Schückert search lights on the four corners of the manufactures building. These lamps are operated from the 180 kilowatt, 120 volt Siemens dynamo, in the British section in machinery hall. Two lamps are of 150 ampères, one of 100 ampères and one of 60 ampères. The diameters are respectively 60 inches, 44 inches, 36 inches and 24 inches. The 60-inch lamp on the northwest corner is the largest and most powerful ever built, and gives a beam having an intensity of 194,000,000 candle-power.

(To be continued.)

HIGH FREQUENCY CURRENTS AND "HARMLESSNESS."*

BY W. S. HEDLEY, M.D. EDIN., M.R.C.S. ENG., &c.

THE high frequency *furore* has invaded the field of physiology and even that of electro-therapeutics. It is possible and probable that on subsidence it may leave behind it results of solid and lasting value. It is conceivable even that our present electrical methods are on the eve of revolution and that currents of high frequency and potential may eventually displace the three conventional forms of current ordinarily used in medicine. In the meantime the physician must keep an open mind—a "level head." His attitude must be that of inquiry, tempered perhaps by a wholesome tinge of scepticism. He must try to make good his way as he goes, and decline to be hurried along in an excited rush over ground that is at best but very insecure. He must often pause to steady his mind and question himself as to the "what" and "how" and "why." The "what" is briefly this: It is well known that certain currents of high frequency (500,000 to 1,000,000 or more alternations a second), strong enough to light lamps which with ordinary frequency require currents that are dangerous to life, may be passed through the human body without producing any very appreciable effect in the way of sensation or neuro-muscular phenomena in the shape of contraction. M. d'Arsonval, who more than anyone else has experimented in this direction, states further: (1) That tissues traversed by such currents become rapidly less excitable, and that an analgesia lasting from one to twenty minutes is produced at the point of penetration; (2) that the vaso-motor system is strongly influenced, as is shown by the fall in blood pressure registered by the manometer in the carotid of a dog or by the Marey sphygmograph in man; (3) that on the continued application of these currents the skin becomes vascular and perspiration follows; (4) that animals submitted to the action of such currents show an increase in the respiratory combustions, as seen by examining definite quantities of blood by the usual physiological methods; (5) that they have an influence on certain micro-organisms as shown by their action on the pyocyanic bacillus (decolouration of blue pus); (6) that the body may be submitted to the action of such currents either by passing them directly through the tissues or placing the tissues or the whole body in the interior of a solenoid (without contact with it). This latter method he calls "auto-conduction." In connection with these observations he mentions two hypotheses: (1) that the current on account of its enormous frequency passes by the surface of the body, as such currents are known to do with other conductors, and (2) that the sensitive and motor nerves are so organised as to respond only to vibrations of a definite frequency, in the same way that the terminations of the optic nerve are "blind" for undulations of the ether of a period less than 497 billions per second (red) or more than 728 billions per second (violet). He rejects the surface theory so far as the animal body is concerned, and though he passed currents of 3,000 milliampères he explains their harmlessness by "absence" of excitation, or rather on the hypothesis that these currents exercise on nervous centres and muscles an inhibitory action of the kind studied by Dr. Brown-Séquard, and he considers that this inhibitory action is shown by some of the phenomena above described. In this country the harmlessness of such currents is generally explained by the fact that there is virtually no current strength (ampèrage). In the *Lancet* of December 24th, 1892, I detailed some experiments with comparatively low frequency currents which seemed to point in this direction. In the ELECTRICAL REVIEW it was pointed out that in all high frequency experiments the current strength is probably very small owing to its being "whittled down" by the various transformations to which it had been subjected. In the *Philosophical Magazine* of February, 1893, Mr. Campbell Swinton offered an explanation of the lamp experiment which is now well known, which has been freely reproduced both in the medical and lay press, and which is now, I think, the explanation most generally accepted. Attempts to form an opinion on such points may be assisted by reasoning of the following kind: Since efficiency varies with the square of the frequency, and since currents of high frequency must have high voltage for conducting the current, it follows that to obtain an exceedingly small current of high pressure and high frequency great power is required to produce it. Supposing that a current whose initial energy is as large as 2 ampères at 200 volts—*i.e.*, about half an electrical horse-power—is transformed up to 100,000 volts, the resulting current strength (ampèrage) cannot be more than 0·004 ampère (4 milliampères). Now if instead of arguing from the initial energy one begins at the other end and takes the amount of work done at the terminals as the basis of reasoning, it occurs to me that a better and more definite point of departure is obtained. What is the actual work done by a current of this kind as it escapes from further manipulation at the terminals of the high frequency coil? I place a 5 candle

* The *Lancet*.

lamp, which on ordinary circuit glows bright red with 250 milliampères at 10 volts, between the terminals of the apparatus described in the footnote * and find that here also it is brought to the same degree of redness. I then substitute my body for the lamp by holding in my hand two copper cylinders. On turning on the current no muscular contraction or sensation beyond a slight warming effect under the electrodes is perceived. After breaking circuit there is perhaps a slight deadening of the ordinary cutaneous sensibility over the same area. Using a half-crown as an electrode on the forearm, there are no effects beyond the above; using a shilling in the same way, there is a slight pricking effect; with a sixpenny piece this becomes more marked and with a threepenny piece painful. I am, therefore, in possession of two facts. In the first place, I have applied to my body, through the area of a threepenny piece, a current which would bring to a red glow a lamp requiring with a low potential current circuit 250 milliampères and 10 volts (2·5 watts). Was I, therefore, passing such a current through my body? Taking my body out of circuit, I approximate the terminals until within sparking distance of each other. This distance measures 1 centimetre. Turning to De la Rue and Muller's sparking table, I find that such a spark-gap requires a pressure of 9,000 volts to overcome it. But the total energy required to glow the lamp is 2·5 watts; therefore, the current strength will fall short of 3 milliampères. If an experimenter, therefore, states that by such an apparatus he has passed 3 ampères (3,000 milliampères) through a man's body, may I, assuming that his spark-gap was not less than 1 centimetre, representing 9,000 volts, conclude that he considers he has passed through the living body a total energy of 27,000 watts, or 36 electrical horse-power? The second point which this experiment shows me, is that painlessness must depend largely on concentration of current (density). It is absent when spread over the area of a half-crown, and present when concentrated through a threepenny piece; mere rapidity of alternation will not therefore *per se* make a current painless. Rapidity will transform and minimise current strength (ampèrage), but when such current strength is concentrated through a sufficiently small electrode (represented in an extreme form by a spark?) it becomes painful. Apart, however, from the physics of the current itself there is that of the conductor—*i.e.*, the body—also to consider—firstly, that ever-varying quantity, resistance, mainly determined, as is known, by the condition of the skin and changing as the skin happens to be dry or damp. The above considerations, looked at collectively, seem to me to point to the probability: (1) that currents of high frequency and potential owe their "harmlessness" mainly to their small current strength, but that the resistance of the body certainly, and the independent conductivity of its surface fluid possibly, as well as other conditions, may play an important part in explaining the occasional harmlessness of currents of ordinary frequency and admittedly large current strength; (2) that sensation and muscular contraction are influenced by the frequency of the alternation, the extent of changes of potential, and the suddenness (brusqueness) with which that change is made—*i.e.*, by the shape of the electrical curve of which these three are factors—three factors whose effective action is determined also by the degree of current strength and its concentration on a given area.

* Large "Apps' coil" with ordinary vibrating contact breaker supplied with current from a C.C. light circuit at 100 volts. With a R. of 9·5 ohms in circuit the ampèrometer registered 6 ampères and the secondary terminals gave a spark of 22 cm. The total initial energy, therefore, equals 300 watts, or, calculating for loss in coil, 225 watts. The terminals of the secondary of the coil were connected one with the inside and the other with the outside coating of two Leyden jars. The discharge of these across an air gap of 8 millimetres excited the primary of a high frequency coil, the primary consisting of ten turns of No. 10 B.W.G., the secondary (placed within the former) of 100 turns of No. 26 B.W.G. immersed in oil, each turn having a diameter of ¾ inch. The secondary gave at its terminals a discharge spark of 1 cm.

ARC AND INCANDESCENCE LIGHTING.

THE incandescence lamp, which is considered the best solution of the problem of dividing the light, has up to the present been very little used where powerful lights are required.

Is the preference generally shown for regulators well founded? When everything has been taken into consideration, is there as much difference between the cost of lighting by the two systems as is generally believed, and is this difference so much in favour of the arc system that the incandescence lamp is to be rejected without further discussion?

A comparison of the cost in both cases would enable us to settle the question once for all, and this is the object of the present article. We will first determine the luminous power of the arc lights.

We will only take into consideration, writes M. Bainville in *L'Electricien*, those arc lights furnished with diffusing globes, as these are most generally used.

The following table, which has been drawn up from the experiments made by M. Rousseau at the Antwerp Exhibition, gives us the consumption of various types of regulators in watts per decimal candle. We will assume that the absorption by the diffusing globes is about 50 per cent., although sometimes it amounts to 70 per cent. The mean spherical intensity has served as the basis of our calculations, and the number of watts consumed per candle is determined for 70 and 110 volts.

i.	E_B	W_B	$w_1 110$	$w_1 70$	I	$I_{(i)}$	$w_2 110$	$w_2 70$
3	47	141	165	210	150	75	2·20	2·80
5	47	235	275	350	300	150	1·83	2·33
6	47	282	330	420	400	200	1·65	2·10
7	47	329	385	490	500	250	1·54	1·96
8	47	376	440	560	650	325	1·36	1·72
10	47	470	550	700	850	425	1·29	1·65
12	47	564	660	840	1,000	500	1·32	1·68
14	47	658	770	980	1,200	600	1·28	1·63
16	47	752	880	1,120	1,500	750	1·17	1·49
18	47	846	990	1,260	1,700	850	1·15	1·48
20	47	940	1,100	1,400	2,000	1,000	1·10	1·40

i, intensity of current in ampères; E_B, difference of potential at terminals; W_B, watts absorbed at terminals; w_1 110, watts absorbed at 110 volts; w_1 70, watts absorbed at 70 volts; I, mean spherical luminous intensity; $I_{(i)}$, actual luminous intensity with diffusing globe; w_2 110, watts absorbed per decimal candle at 110 volts; w_2 70, watts absorbed per decimal candle at 70 volts.

We can now commence the study of the cost, beginning with that of arc lighting, which is somewhat complicated.

COST OF ARC LIGHTING.

To simplify our calculations and show a more general result, we will classify the expenditure under various heads: raw material, plant, labour, and current, which we will consider in succession.

Raw Material.—The carbon is the only material consumed in the regulator. We have calculated this expenditure per hour of lighting for arcs working at different intensities.

Intensity of current in ampères:—3, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20.

Cost in centimes per hour:—1·1, 1·2, 1·4, 1·5, 1·8, 2·2, 2·5, 2·9, 3·2, 3·7, 4·5.

Plant.—The cost of the plant includes the depreciation, repairs, the breakage of globes, and the wear and tear of the rheostats.

We may assume that this expenditure amounts on an average each year to 30 per cent. of the original outlay. Taking 150 fr. as the mean cost, including all accessories, the daily expenditure amounts to ·13 fr. The expenditure per hour thus depends on the number of hours of lighting.

Electrical Energy.—The cost of the electrical energy is easily estimated; but this expenditure varies greatly according to the conditions of production. Thus, in towns, the hecto-watt-hour is sold at from ·06 to ·12 fr., in industrial circles its cost varies from ·005 to ·03 fr. Thus several cases must be considered. We will take four extreme cases. In the following table the cost per hour is shown in centimes, in each of these four cases for regulators of different intensities, for the two most general cases of 110 and 70 volts:—

No. of candles.	Intensity of the lamp in amperes.	Private works.				Central stations.			
		Hecto-watt hour at ·5 c.		Hecto-watt-hour at 3 c.		Hecto-watt-hour at 6 c.		Hecto-watt-hour at 12 c.	
		110 v.	70 v.	110 v.	70 v.	110 v.	70 v.	110 v.	70 v.
		c. per hour.		c. per hour.		c. per hour.		c. per hour.	
75	3	0·825	1·050	4·950	6·300	9·900	12·600	19·800	25·200
150	5	1·375	1·750	8·250	10·500	16·500	21·000	33·000	42·000
200	6	1·650	2·100	9·900	12·600	19·800	25·200	39·600	50·400
250	7	1·875	2·450	11·550	14·700	23·100	29·400	44·200	58·800
325	8	2·200	2·800	13·200	16·800	26·400	33·600	52·800	67·200
425	10	2·750	3·500	16·500	21·000	33·000	42·000	66·000	84·000
500	12	3·300	4·200	19·800	25·200	39·600	50·400	79·200	100·800
600	14	3·750	4·900	23·100	29·400	46·200	58·800	92·400	117·600
750	16	4·400	5·600	26·400	33·600	52·800	67·200	105·600	134·400
850	18	4·750	6·300	29·700	37·800	59·400	75·600	118·800	151·200
1,000	20	5·500	7·000	33·000	42·000	66·000	84·000	132·000	168·000

Labour.—This item, which is far from unimportant, and which constitutes one of the disadvantages, is somewhat difficult to determine. It is, moreover, very different in different installations, as we have to take into account the importance of the installation, the district in which it is situated, the price of labour, the number of hours of lighting, and the kind of installation under consideration. In the first place, to calculate this item we must divide installations into two groups:—

1. Installations for the lighting of works or factories, in which case the lighting is merely an accessory of the establishment.

2. Installations for the lighting of towns, in which case the lighting constitutes a special industry—central stations.

1. *The Lighting of Factories or Works.*—In this case, whatever may be the extent of the lighting, one or more special *employés* must be appointed to supervise the working of the regulators, attend to them, adjust the carbons, &c. This duty cannot be entrusted to the ordinary engine-man, although he can very well attend to the dynamo which supplies the current; in other words, the duty of the electrical staff is mainly to attend to the lamps. Under these conditions, it is evident that the cost of labour will depend on the number of regulators in use. Thus this item varies with each case. However, if we estimate at one hour's work the time taken up in replacing the carbons, cleaning the lamp, removing and cleaning the globe, including supervision during work, we should be very near the truth in the majority of cases. If, on the other hand, we reckon on an average duration of six hours, the cost of labour comes out at ·10 francs per hour of lighting.

2. *Central Stations.*—Here the number of regulators supplied is greater; the current is necessarily more regular than in the preceding case, so that less supervision is required; but, on the other hand, the lamps require more scrupulous attention. I think, therefore, we must estimate the time demanded by each regulator at half an hour's work, including displacements. The cost of lighting per hour amounts, then, in this case, to ·05 francs.

It is by assuming the conditions to be normal that we have arrived at 10 and 5 centimes per hour of lighting as the cost of maintenance of the lamps; we have not taken into consideration the numerous cases in which the working of the regulators becomes quite defective. Irregularity in the working of the dynamos, air saturated with moisture, acid vapours, a quantity of dust, powerful vibrations, strong currents of air, are all influences which impede the good working of regulators, necessitate constant repairs, and render their employment very difficult and very expensive.

Cost of Incandescence Lighting.

The cost of incandescence lighting is much more easily determined than that of arc lighting. We have simply to consider the cost of the electrical energy expended and the cost of the lamps. We will estimate it in the four special cases corresponding to the initial consumption of 2, 2½, 3 and 4 watts per decimal candle. We will take, as the duration of the lamp, the time during which their luminous intensity remains practically constant.

For lamps of 2 watts we will assume that this duration is about 150 hours, for those of 2½ watts, 300 hours, for those of 3 watts, 600 hours, and for those of 4 watts, 1,000 hours.

The accompanying table gives the cost per hour of the lighting, including the depreciation for lamps of different luminous powers working at the wattages shown above, in the four cases of the price of electrical energy which we have already assumed.

Comparison between the Cost of the two kinds of Lighting.

We have taken four extreme cases in considering the

Number of candles.	Price of lamp.	Private Works and Factories.								Central Stations.							
		Hecto-watt-hour at ·5 c.				Hecto-watt-hour at 3 c.				Hecto-watt-hour at 6 c.				Hecto-watt-hour at 12 c.			
		Watts per candle.				Watts per candle.				Watts per candle.				Watts per candle.			
		2	2½	3	4	2	2½	3	4	2	2½	3	4	2	2½	3	4
		c. per hour.				c. per hour.				c. per hour.				c. per hour.			
100	6	5	3·25	2·50	2·60	10	9·5	10	12·6	16	17	19	24·6	28	32	37	48·6
150	7	6·2	4·25	3·45	3·70	13·7	13·65	14·7	18·4	22·7	24·9	28·2	36·7	40·7	47·4	55·2	72·7
200	8	7·3	5·1	4·3	4·80	17·3	17·6	19·3	24·8	29·3	32·6	37·3	48·8	53·3	62·6	73·3	96·8
250	10	9·1	6·73	5·45	6	21·6	22·05	24·2	31	36·6	40·8	46·7	61	66·6	78·3	91·7	121
300	10	9·6	7·05	6·2	7	24·6	25·8	28·7	37	42·6	51·6	55·7	73	78·6	93·3	109·7	145
400	12	12	9	8	9·2	32	34	38	49·2	56	64	74	97·2	104	128	146	193·2
500	14	14·3	10·85	9·8	11·4	39·3	42·1	47·3	61·4	69	79·6	92·3	121·4	129·3	159·3	182·3	241·4
600	16	16·7	12·9	11·7	13·6	46·7	50·4	56·7	73·6	82·7	95·4	110·7	145·6	154·7	190·7	218·7	289·6
700	20	19·3	15·35	13·8	16	54·3	59·1	66·3	86	96·3	111·6	129·3	170	180·3	222·3	255·3	338
800	25	24·7	18·4	16·2	18·5	64·7	68·4	76·2	98·5	112·7	128·4	148·2	194·5	208·7	256·7	292·2	396·5
1,000	35	33·3	24·1	20·8	23·5	83	86·6	108·8	123·5	143·3	161·6	185·8	243·5	263·3	323·3	365·8	483·5

Number of candles.	Hecto-watt-hour at ·5 c.			Hecto-watt-hour at 3 c.			Hecto-watt-hour at 6 c.			Hecto-watt-hour at 12 c.		
	Incandescence.	Arc.		Incandescence.	Arc.		Incandescence.	Arc.		Incandescence.	Arc.	
		110 v.	70 v.		110 v.	70 v.		110 v.	70 v.		110 v.	70 v.
		c. per hour.	c. per hour.		c. per hour.	c. per hour.		c. per hour.	c. per hour.		c. per hour.	c. per hour.
100	2·50	13·085	14·110	9·5	18·21	19·56	16·00	18·16	20·86	28·00	28·06	33·46
150	3·45	14·735	15·110	13·65	21·61	23·86	22·7	24·86	29·36	40·7	41·36	50·36
200	4·30	15·210	15·660	17·6	23·46	26·16	29·3	28·36	33·76	53·3	48·16	58·96
250	5·45	15·535	16·110	22·05	25·21	28·36	36·6	31·76	38·06	66·6	54·86	67·46
300	6·20	16·160	16·760	25·6	27·16	30·76	42·6	35·56	42·56	78·6	61·76	76·16
400	8·00	17·110	17·860	34·00	30·86	35·36	56·00	42·36	51·36	104·00	75·36	93·36
500	9·80	17·960	18·860	42·1	34·46	39·86	69·00	49·26	60·06	129·3	88·86	110·46
600	11·70	18·810	19·960	50·4	38·16	44·46	82·7	56·26	68·86	154·7	102·46	127·66
700	13·80	19·760	20·960	59·1	41·76	48·96	96·3	61·16	77·56	180·3	115·96	144·76
800	16·20	20·610	22·160	68·4	45·56	53·66	112·7	70·26	86·46	208·7	129·66	162·06
1,000	20·80	22·160	23·660	86·6	49·66	58·66	143·3	77·66	95·66	263·3	143·66	179·66

price of electrical energy, we will therefore make the comparison in each case.

The foregoing table enables us to see at once which mode of lighting is best suited to each particular case.

1st case.—The price of the unit of energy is ·005 franc; this relates to works employing hydraulic power or situated near coal mines. In this case we see that the most advantageous incandescence lamp to use is not that which consumes the least energy, but the 3-watt lamp. Taking all the luminous powers into consideration, the incandescence system is cheaper than the arc system. We need not, therefore, dwell upon the irregularities of arc lighting when making our choice.

2nd case.—When the price of the unit of electrical energy amounts to ·03 franc, the advantage of the incandescence system does not at first sight seem to extend beyond 400 candles, and we can employ either the 2-watt or the 2½-watt lamp. But as we now seldom use a regulator of higher luminous power, we may say in this case also, without referring to any other reasons, that preference must be given to incandescence lighting.

In short, in works and factories incandescence lighting has the advantage from an economical point of view. If to this we add the other advantages gained by its use, the greater regularity of working, the greater steadiness of the light, the greater simplicity of the installation, involving fewer chances of accidents and stoppages, the absolute security from the danger of fire, which we do not get with the arc system, both on account of the projection of the carbons and the heating of the rheostats, we see that even for the greater luminous intensities, incandescence stands first.

3rd case.—For central stations, where the price per hecto-watt is not very high, incandescence lamps may be employed with advantage up to 300 candles, if we judge by the table; but it is also evident that in certain cases, when the supervision of regulators becomes difficult, it will be worth while to carry the incandescence system beyond this point.

4th case.—In this case, as in the preceding one, the 2-watt incandescence lamp is the one to be used. Here it is only to our interest to substitute incandescence lighting for arc lighting for low luminous powers; but we may remark in passing that the arc lights generally used in towns seldom exceed the 5-ampère type (about 150 candles), and for these intensities the prices of the two systems is exactly the same.

In towns, therefore, incandescence lighting can with advantage be substituted for arc lighting in all cases where very powerful lights are not required. It is very certain that the consumer of electrical energy will not fail to perceive these advantages, and, in fact, a great number of industrial consumers are already thinking of substituting incandescence lamps for their regulators, being persuaded that this new solution of the problem will be better suited to their requirements.

ELECTRICAL ENGINEERING AT THE WORLD'S FAIR.

[FROM OUR SPECIAL COMMISSIONER.]

IX.

THE General Electric Company's exhibits (the combined Thomson-Houston and Edison Company), are very extensive. They cover a very large floor space, but, after all, contain nothing of great novelty. At one stand they show a great variety of incandescent lamps, arranged in historical order, from an American point of view, beginning with Edison's first experimental lamps; there is nothing worthy of note in such an exhibit, forming a sort of museum showing Edison lamps. At this stand, two models are also shown, illustrating the quantity of copper required to supply current to the same number of lamps on the two-wire and on the three-wire systems. The models, of course, show a great saving in copper in favour of the three-wire system with feeders; this exhibit contains the original Edison dynamos with the very badly designed magnets. Evidently the object is to impress the early work of Edison on the visitor.

Their next exhibit is one of motors and dynamos, Edison dynamos made on the Hopkinson lines, and various types of motors, all of which have been shown and described over and over again. Another exhibit shows more motors, still of the same kind, applied to various mining machines. In this exhibit are shown three-phase motors of the kind made familiar to European electricians at the Frankfort Exhibition; at another of their stands they show engines and dynamos for isolated plants; at another stand the Thomson-Houston dynamos for arc lighting are shown driven by a Hopkinson-Edison motor; at another stand, Thomson's experimental apparatus for alternating currents and alternating motors are shown, all of which are old and have been before shown and described. Here, also, is shown an induction coil giving about 3 feet sparks with which the young men in attendance attract quite a crowd to see the artificial lightning; at another stand they show electric welding. Altogether, this company have seven separate stands in the best part of the Electricity Building, and these are filled up principally by lines of the same dynamos and motors, all alike, but of different sizes; besides this, they have a large place as a sort of office, in a portion of which are shown the Elihu Thomson meters; altogether, the points of novelty and interest to be observed by electricians in these huge exhibits, amounts to very little indeed. Elihu Thomson's original models are, perhaps, the most interesting things in the collection.

The Pelton water-wheel is shown driving an alternator, direct-coupled. This water-wheel is the only one shown in connection with dynamos in the Electricity Buildings; it is also shown at the Westinghouse exhibit.

This water-wheel is essentially a high-speed wheel, and is, therefore, adapted to dynamo driving direct-coupled. It, however, has the serious drawback that it must be placed at the lowest level of the waterfall if the whole fall is to be utilised.

The Stanley Company of Pittsfield, in a corner of the General Electric Company's space, show the double armature two-phase motors for alternating currents, described in the ELECTRICAL REVIEW of June 23rd; it is used to run a large fan.

The Fort Wayne Electric Company show a very large collection of arc incandescent and alternating dynamos, arc lamps, transformers, and meters. Their arc dynamo is of the old familiar B Gramme type, with an abnormally big armature, fig. 1. It has an electro-magnetic regulator, which

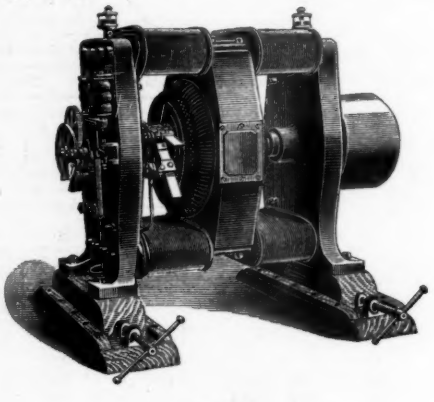


FIG. 1.

shifts the brushes to increase or decrease the E.M.F. If there is anything which impresses the electrician here more than anything else in connection with dynamos, it is the persistence of old types of dynamos and the old devices for regulating them, long ago obsolete in Europe, yet it seems that they can be still sold and used in America.

Another type of dynamo becoming very common here (and also in Britain), is shown by the Fort Wayne Company in many sizes; this is the single bobbin dynamo, as shown in fig. 2. This company have them made with the bobbin under and the armature over it; most of the others make them with the bobbin upright, a form which has the advantage of less magnetic leakage when bolted down to an iron bedplate. This company's arc lamps and transformers do not call for any special notice; the meter shall be referred to again.

The Mather Company of Manchester, Conn., show in a very large space, dynamos with circular wrought-iron field

magnets, and also large four and six pole dynamos, there being nothing noteworthy to be seen in these except that the field magnets being circular, requires to be wound by hand, and is, otherwise, an expensive form, and has no advantages

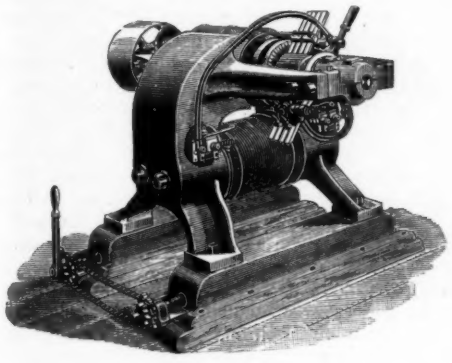


FIG. 2.

over simple straight-limbed magnets. The same remarks apply to the C. & C. motors and dynamos as shown in fig. 3; the curved magnets are expensive to fit together, must be wound by hand, and are no better than straight machine wound magnets would be. It would be very interesting to hear upon what theory these curved field magnets are designed. Upon ordinary theory they seem to be absurdities.

and motors of the single bobbin type. These are all common dynamos with no noteworthy features.

In dynamo details, the general use of carbon brushes is remarkable. They are used alike on dynamos and motors;

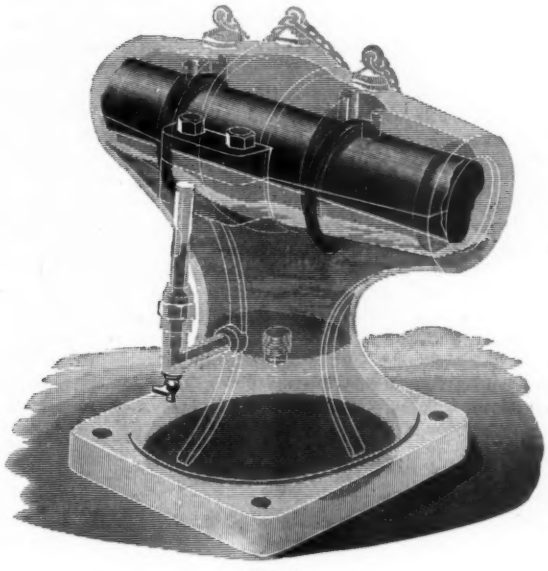


FIG. 5.

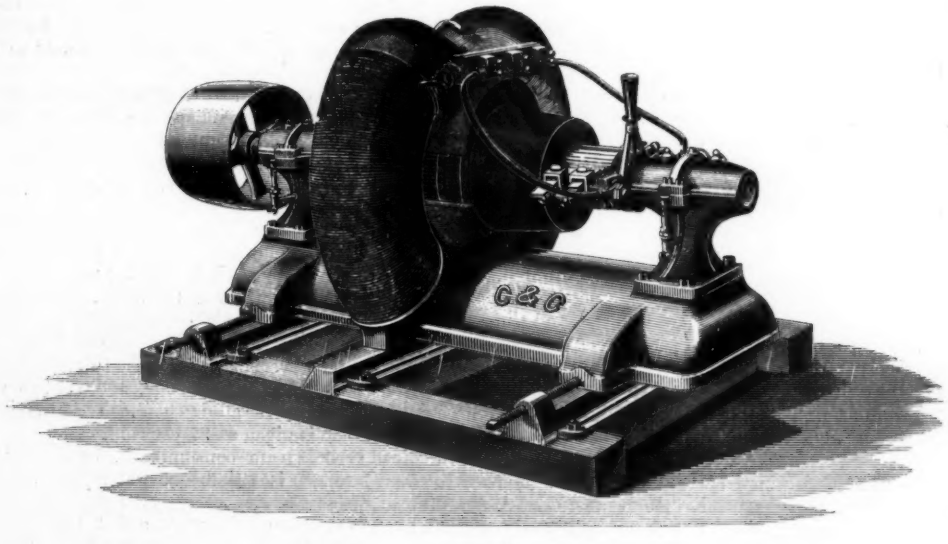


FIG. 3.

FIG. 4.

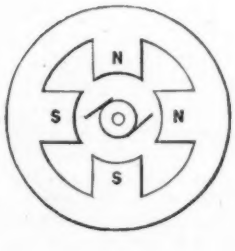


FIG. 6.

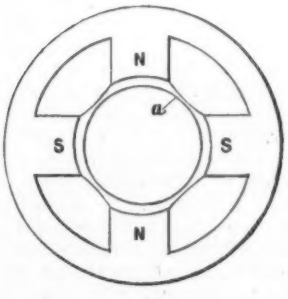


FIG. 7.

The Eddy machine is also shown in many sizes; also the Perret dynamo, a four-polar machine; also the Standard dynamo, a dynamo exactly like that known as the Manchester dynamo in England. The Jenney Company show dynamos some use flat plates of carbon, others use numerous square rods, each fed forward by separate springs.

Fig. 4 shows a special carbon brush holder, by the C. & C. Company, called a re-action brush holder. Utilising the tangential pressure of the commutator on the brush, the tension on the brush has been greatly reduced. The brush having

both ends bevelled, rests on a flat surface, and is forced down by means of a curved arm actuated by a spring. These holders work equally well in either direction, and are, therefore, adapted for reversing motors.

Self-oiling and self-aligning bearings are also more common on American dynamos. Fig. 5 shows a very good example. They are sleeves of good white metal casts, having a spherical shoulder fitting into the ball socket of the pedestal. The oil is carried to the bearing by means of brass rings, rolling on the shaft, through grooves in the bearing.

The Western Electric Company show a dynamo with four poles, two S.S. and two N.N., a rather peculiar arrangement, see fig. 6. This arrangement would be good in large machines to prevent cross magnetisation by the armature current. Another still more peculiar field magnet is to be seen at the German exhibit of the Electricitat Allgemeine Gesellschaft, shown in diagram, fig. 7. Here, a cast-iron cylinder is bored out to fit the armature, and turned to fit into the poles, as at A. One would imagine that such a construction would short circuit, magnetically, the poles, but it seems to work well, as no signs of sparking or heating or other losses are discoverable. The thin part of the cylinder, between the poles, is drilled by holes, cutting away some of the metal, and for ventilation.

CENTRAL ELECTRIC LIGHT STATIONS.

No. 11.—CAMBRIDGE ELECTRIC LIGHT SUPPLY.

WHATEVER may be said of the comparative enlightenment of the two Universities, the town of Cambridge has followed, somewhat tardily, the example set by Oxford in the matter of electric lighting. This delay has arisen mainly through the inertness of the municipal authorities, who were for a long time undecided as to whether or not they would undertake a supply themselves. Finally, they sold their powers to a company which was financed, to a great extent, by local capital. Practically, the supply commenced to a few lamps at the end of last year, but it is only recently that a fair load has been obtained. The principal consumers at the present moment are the colleges, which have over 2,000 lamps connected, but there are probably not more than 20 or 30 private houses and a few shops lighted, consequently the vacation brings an exceedingly quiet time to the generating station. There is no street lighting, and the probability is that there will be none for some time to come, for, although the Corporation are much disposed to light their streets by electricity, the contract with the gas company will not expire for a long time.

THE SYSTEM.

The system in use at Cambridge embraces features which are by no means common in central station practice. A 2,000-volts alternating current with house transformers has been adopted. Little or no difficulty was experienced in placing transformers within the college precincts; in fact, the colleges have, in most cases, built their own transformer chambers. With the notable exception of the generating station of the Newcastle and District Electric Lighting Company, the Parsons steam turbine, which is used at Cambridge, is practically new to central station work. We have occasionally referred to the vast improvements made by Mr. Parsons in his turbine during the past few years. In November of last year, when commenting upon Prof. Ewing's report, we pointed out that the economy of steam effected was remarkably good. It was then our impression that still better results might be obtained, and we are glad to say that Prof. Kennedy's recent report, published in our issue for July 28th, shows that the output of the combined turbine and alternator has been greatly improved. These improvements, to some extent, were suggested by us in our review of Prof. Ewing's report, and the idea of treating the turbines as a series system put forward then has been found to be correct. The indefatigable labours of Mr. Parsons have resulted in a combination which, on the grounds of economy, will compare with the best engines; on the grounds of convenience the turbo-alternator possesses distinct advantages over any other form of motor.

THE GENERATING STATION.

The generating station, which is situate on the banks of the Cam, at no great distance from the centre of the town, contains three sets of steam turbine alternators, each designed for a maximum output of 150 units. The combination is fitted with the latest automatic electrical governor. The engine room is 50 feet long and 35 feet wide, sufficient space being left for three more sets of plant, each of an output of 300 units. The boiler house consists of one bay, 60 feet by 35 feet, and contains two Lancashire boilers, 30 feet long by 7 feet 6 inches diameter, a Green's economiser consisting of 96 tubes, a steam superheater and a Berryman's feed water-heater. In addition are two duplex feed pumps. It is so arranged that when it becomes desirable to erect the larger plants, two more bays, capable of holding four additional boilers with economisers, steam superheaters, &c., can be added. The chimney is built of a size sufficient for five boilers working simultaneously.

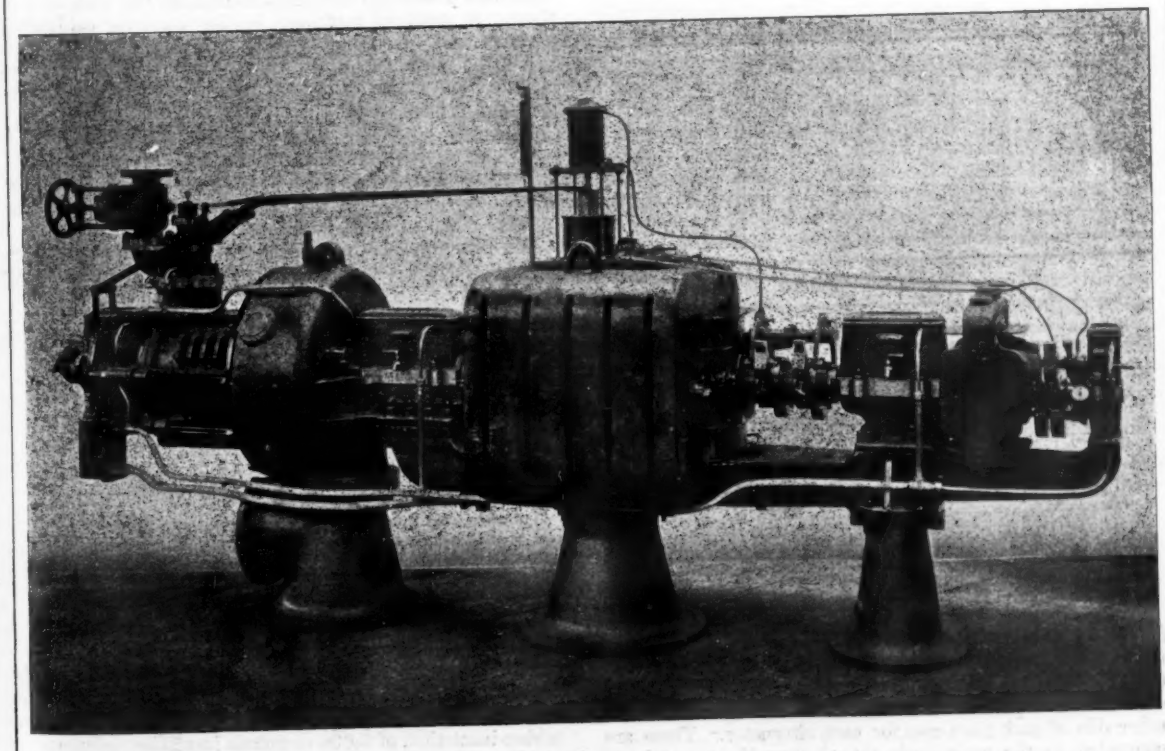
The steam pipes are on the ring system, and admit of the steam being taken either through the superheater or direct to the plants. The auxiliary engines can be worked off either range of pipes. All other pipes, including connections to condensers, water-feed and suction pipes, and connections to feed-heater and economiser, are in complete duplicate. The heating of the steam on its passage from the boilers to the engines, is a special feature in this station, and affects, no doubt, a considerable economy in fuel. It will be remembered that in our published tests of a few weeks ago, Prof. Kennedy said "the construction of the motors allows the advantage of superheating to be carried to the fullest extent, without any chance of injury to any parts of the machine, and, no doubt, this wise use of superheating has contributed to no small extent to the exceptionally good results which have been obtained." Since these trials were made, Prof. Kennedy has found that at 100 E.H.P., the difference of economy between superheating and heating is about 8 per cent., which is an exceedingly important figure.

Each plant is entirely independent of the others, and consists of a compound steam turbine arranged for multiple expansion from the boiler pressure to a condenser pressure of 1 lb. per square inch absolute, or a range of about 150 fold expansion. The motor revolves at 4,800 revolutions per minute, and is coupled direct to a two-pole alternator giving 75 amperes at 2,000 volts, with a periodicity of 80 per second; to the same shaft is coupled the exciter, as will be seen from our illustration of the plant. The whole plant is self-contained, and stands on rubber blocks in a saveall without being bolted down. An automatic variable cut-off valve gear and governor, enables the full range of expansion to be maintained at light loads, and secures considerable economy of fuel on the all-day load. The electrical efficiency of the dynamo is given as 97 per cent. from one half-load to full load; the steam consumption, as recorded in Prof. Kennedy's report, is 19½ lbs. of water per electrical H.P. at full load.

The jet condensers differ somewhat from the usual type and merit our attention. A separate water pump is placed below the condenser, no injection water being admitted to the air pump, which is placed above, and is of the compound type. The power required is thus reduced to a minimum, and the air pump valves being clear of water a free flow of air and water vapour is secured. The pumps are worked from the crosshead of a small auxiliary engine, the power absorbed being only about one per cent. of the power developed by the main engines, and a vacuum of 28½ to 29½ inches is maintained.

The exhaust steam from the condenser engines and feed pumps is utilised in the Berryman's feed-heater previously mentioned, and at light loads it heats the feed water to 140° Fah. before passing into the economiser and thence to the boilers. The water for condensing as well as the feed, is drawn from a tank into which the river water flows through a duplicate system of strainers controlled by sluice valves, which admit of frequent cleaning while at work, should such be necessary during times of flood. The exhaust pipes are so arranged as to admit of any plant being connected to any condenser, or of all being connected together. The whole of the steam and exhaust pipes are carried under the engine room floor and a branch brought up to each plant. This plan certainly reduces the possibility of escaped steam affecting the

VIEW OF TURBO-GENERATORS IN GENERATING STATION.



TURBO-GENERATOR.

dynamos or electrical instruments. Six feet of head room is allowed under the floor, so that all the pipes can be easily inspected and joints made.

The small engines and the condensers are placed on one side of the engine room, each being close to the steam turbine alternator which it serves, and the steam connections are so arranged, that when starting or stopping, the attendant has all the hand-wheels within easy reach.

A 3-ton travelling crane is erected over the machinery, and is large enough for all purposes.

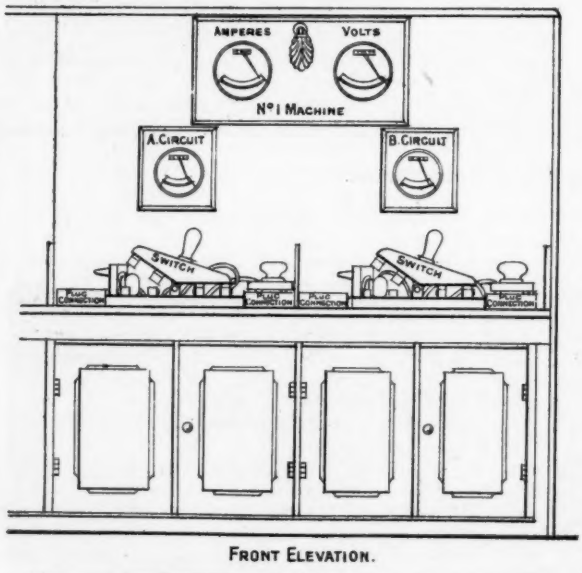
NO PARALLEL WORKING.

It is considered by the contractors that parallel working is not desirable on account of the small consumption of steam by the turbines at light loads. In speaking of Prof. Ewing's report last year, we expressed our conviction that, granted the turbines were economical at half load, parallel running would be advantageous. We ventured to suggest that there might possibly be difficulties in the way of synchronising at high speeds; whether this is actually the case or not we have no means of telling.

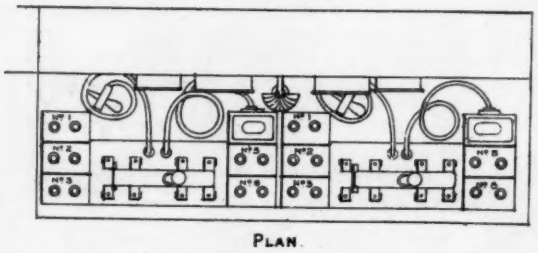
SWITCHING ARRANGEMENTS.

There are five separate circuits, and a consideration of the switching arrangements will be useful. The charging switches, instruments and connections, are mounted on a stand, running half the length of the engine room and facing the plant.

The system of switches is decidedly simple. Figs. 1, 2 and 3, give an elevation, plan and cross section, of the arrangements.



FRONT ELEVATION.

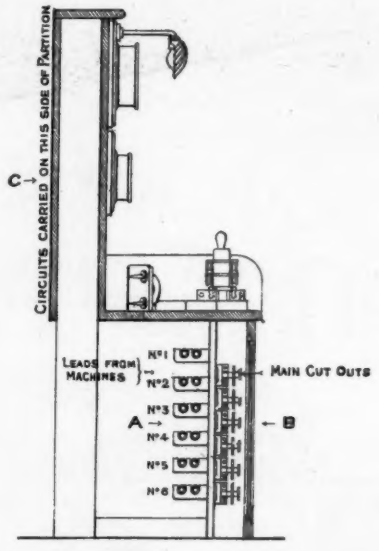


PLAN.

FIGS. 1 AND 2.

From each alternator two cables are carried on the pegs (at A, fig. 3) the whole length of the stand, numbered in the same manner as the alternators. On the front of this partition (at B) are secured the main fusible cut-outs, there being to each switch a positive on one side and a negative on the other side of each glass case for each alternator. These are connected to the main leads (at A) from the top pair (a positive and negative set), connections are taken to two plug sockets mounted on a porcelain base, the second pair are taken to another plug socket, and so on with all the others. The plug sockets are secured on each side of the changing switches, the latter having two flexible leads, with plugs on the end, fitting into these plug sockets.

In switching over, the disengaged flexible lead of either switch is inserted into the plug socket, numbered the same as the alternator to be connected, and by pushing over the lever the change is instantaneously made.



SECTION.

FIG. 3.

The leads from each switch are fitted in suitable casing at the back of the partition (at C), and a passage is left between it and the wall, so that all the cables can be overhauled and properly inspected.

An ampèremeter is permanently inserted in each external circuit, and is placed directly over the switch.

Opposite each steam turbine alternator, an ammeter, voltmeter and pilot lamp are placed to indicate the work of each plant. A standard voltmeter is also fitted for calibrating purposes, and a recording meter is sometimes added.

All the switches, plug connections, and cut-outs are mounted on special porcelain bases, and all instruments mounted on slate bases.

THE CONSUMPTION.

The capacity of the station at the present moment is 300 units, but it is expected that the ultimate capacity will be equal to 30,000 10-C.P. lamps.

We have previously mentioned that the principal customers are the colleges; the number of lights in each college being as follows:—

Trinity	600
St. John's	300
Caius	200
Clare	200
King's (extensions coming on)	100
Queen's	50
Downing	100
	1,550

In addition, Prof. Ewing takes a supply from the mains for the purpose of lighting his workshops. The various physical laboratories are also lighted, the anatomical having three arc lights and 150 incandescent lamps. The price per unit is 7d.

THE MAINS.

The mains are divided into five separate circuits; the voltage, as before stated, being 2,000. The mains are made by the Silvertown Company, and are of the best vulcanised rubber insulation, of 5,000 megohms insulation resistance per statute mile, and specially protected by an outside sheathing of tape. They are drawn into cast-iron pipes, specially smoothed internally, and coated with bitumen compound;

they are lead-jointed and perfectly watertight. Cast-iron boxes are placed every 50 yards, for drawing-in purposes and to connect customers. The covers rest on a rubber ring, forming a joint with the box, and the whole system is designed to be water-tight and gas-tight. To prevent the lodgment of gas, a Thwaites blower at the station forces dry air through the system.

TRANSFORMERS.

The transformers are of Elwell-Parker and Parsons type; they are placed in cellars, or similar fireproof places on the consumer's premises, and are cased in accordance with the Board of Trade regulations. High and low-tension fuses protect the transformer and the consumer's wiring from excessive current, and earthing devices from excessive potential in the secondary.

THE COST OF THE SYSTEM.

At the present moment about £26,000 has been spent.

GENERAL.

It would be difficult for us to give a fair notion of what are the earning prospects of this company. The probabilities are that a very fair and steady load will be ensured from the colleges alone, although at the moment rather less than 2,000 lamps are connected. We do not know what are the expectations of the company with regard to shop and residential lighting, but during the winter months, when there are usually a large number of persons residing in Cambridge, there should be a fair demand. The plant which has been installed should be capable of keeping the cost per unit at a low figure, and considering that the capital of the company is not very large, there should be a prospect of sound business. Of course, these are conclusions drawn only from our own observations; no doubt in a year's time, when we are able to inspect the company's accounts, we shall be better able to tell our readers more about the financial standing of the company.

The resident engineer is Mr. Arthur Ellis, who before his appointment was with Messrs. Parsons, and helped to erect the plant at the station. Our thanks are due to him for his courtesy in showing us the various parts of the system, also to Messrs. Parsons for much of the foregoing information.

ELECTROCUTION.

ONE of the physicians (Dr. J. W. Brown, M.D.), in attendance at the recent execution by electricity at Auburn, when the first attempt to electrocute the condemned man failed, has written a lengthy letter to the New York *Medical Record*. We extract the following:—

"As one of the physicians in official attendance upon the recent electrocution of W. G. Taylor, of Auburn, upon July 27th, 1893, our experience may prove worthy of more than passing notice when viewed scientifically, and perhaps valuable as establishing some data regarding accidents from contact with industrial currents that are so liable to occur now that alternating currents of high tension are so generally employed.

"The writer, with Drs. Conway, of Auburn, Mooney, of Syracuse, and Wright, of Skaneateles, were requested by Warden Stout to assume charge of the execution, and together with the other witnesses proceeded to the electrocution chamber at 12.40 p.m. We were barely seated when electrician Davis turned the current through the bank of incandescents resting in the chair, the voltage registering 1,260, and everything working satisfactorily. . . . . Taylor walked firmly and seated himself in the chair with a wonderful firmness of demeanour. . . . . All retired from the platform, the signal was given, and with a crash the legs shot forward and upward, tearing the standard and entire front from the chair. For exactly 52 seconds this condition was sustained, and at 12.47 p.m. the current was shut off. The condemned now pitched forward, and would have fallen upon his face had he not been restrained by the straps. For 20 seconds he remained apparently dead, a slight froth oozing from the mouth below the mask, when, to our horror, he gasped. The signal was again given, but no current responded to the rapid working of the lever. At the announcement by the electrician that no current was available, Dr. Mooney stepped to the side of the victim and could feel no pulse. Perhaps 30 seconds after I found a slight thready pulse upon the opposite side. . . . . We unbound him and laid him upon the cot and removed him to an adjoining room. . . . . Breathing continued laboured but increasing in frequency. . . . . He now made the first movement of left foot and in a very few moments became restless, moving legs and arms and rolling from side to side. Dr. Conway now administered ½ grain morphia hypodermically at 1.18 p.m. After 15 minutes, no appreciable effect being produced, the writer applied the cone saturated with ¼ chloroform and ¾ ether. He opened his eyes and tried to object to its administration at 1.36. Forty-eight minutes after contact pulse now numbered 130 and was full and vigorous. He readily responded to anæsthetic and was placed in the chair, and second contact was made at 1.55 p.m. This continued 40 seconds, and examination then proved him dead from a voltage of 1,220. . . .

"To summarise, 1,260 volts passed for 52 seconds through the body with entire absence of heart's action at first observation, but within a few seconds becoming marked, and entire absence of motion for exactly half an hour, and with undoubted return of consciousness within the next 20 minutes without resorting to any means for resuscitation. The unfortunate accident was valuable in teaching the authorities that in connection with electric plant established by the State, the advisability of having city system attached to the switchboard, whereby the mere turning of a switch would obviate a repetition of this accident, and yet not entail the expense of a duplicate system. The chair also should be strengthened upon the front and properly braced with bolted attachments, not screwed down, as in this instance; contact should be made by properly insulated metal plates attached to the arms of the chair, the bare feet resting upon properly insulated metal plates, thereby obviating the extra resistance of hair and cranial bones, for while the abnormal muscular development in the present case might not be present again, yet no chances should be taken. Notwithstanding the objections raised by the many opponents of the system and in the face of the unforeseen combination of circumstances present in this instance, it is to-day by far superior as a scientific means of execution to any heretofore devised. Too much credit cannot be given Warden Stout for the expeditious manner in which he solved the problem and introduced other means for the completion of the mandate of the courts, and so as not to prolong the agony or further torture the condemned."

CORRESPONDENCE.

Electrical Engineering at the World's Fair.

I have seen the remarks of Mr. Dallas on the railway motors described in my articles on the above show. He is altogether mistaken in regard to my meaning in saying that all the tramway motors at the exhibition were designed with weak fields and strong armatures. I made no reference whatever to the saturation curve during the working of these motors, further than to point out that at the starting, when a very large current flows in the magnets, these fields must be over-saturated; if they are not over-saturated at the start, then they must be far below saturation at their ordinary speed, and that is, perhaps, a worse fault than the over-saturation at the start.

I made no reference whatever to the state of saturation in the armature. Reliable information was difficult to get at Chicago from attendants; one had to estimate and judge for himself. I therefore made no statements of figures regarding the armature saturation. I don't know whether Mr. Dallas means to convey that the figures quoted by him are taken from a tramway motor shown at Chicago.

A reference to Mr. Dallas's own article, p. 571, fig. B, May 12th, 1893, ELECTRICAL REVIEW, will show what I mean by my condemnatory statement regarding American tramway motors. Just look at the size of the armature compared with the exceedingly small field; the state of saturation of either one or the other makes no difference in the comparison. Their magnetic saturation may be anything you please; the total magnetic flux due to the field magnets is small, very much smaller than that in any good motor of the same power; and the magnetic effect of the large armature, considered as a magnet excited by the armature winding, must be very much greater than that in good motors of the same power designed according to the best practice in Great Britain.

Mr. Dallas states in this same article that "*a railway motor field is always fully saturated;*" that being so, my contention is proved out of Mr. Dallas's own mouth, because if always fully saturated, they certainly must be far over-saturated at the start, when the exciting current is double or treble its normal value.

I did not condemn all the motors at the show; the Westinghouse motor for railways was pointed out to be in accordance with theory and practice in the proportions of armature and field magnet. The total magnetic flux in these motors is comparatively great, hence a smaller armature gives the necessary torque, and it would be easy to get the same torque with a still smaller armature by still further increasing the dimensions of the field magnet. I think Mr. Dallas will now catch my meaning.

Your Commissioner.

Running Arc Lamps.

As a subscriber to your valuable paper, I take the liberty of soliciting some information from you on a point which at present puzzles me.

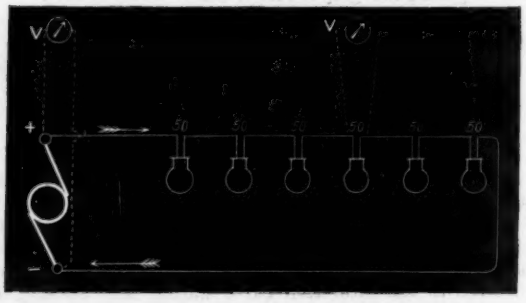
Regarding arc lighting in series, let me suppose a circuit of six 50-volt 10-ampère arc lamps in series; the total lamp voltage of such a circuit will, of course, be 300.

My point is, does the first lamp receive the full voltage, the second 250 volts, the third 200 volts, and so on, the voltage through each lamp decreasing by 50 as it passes on to the extreme lamp at furthest point from dynamo?

An answer will very much oblige.

Henry Calder.

[No; the full voltage of 300 is only found between the terminals of the machine. Each lamp, the first as well as



the last, has the same pressure, viz., 50 volts between its terminals. See sketch, where V represents the voltmeter.—EDS. ELEC. REV.]

OBITUARY.

E. H. MARIÉ-DAVY.

BORN at Clamery on April 2nd, 1820, Marié-Davy died on July 17th last, at the age of 73. Educated at the Ecole Normale Superieure, he was Professor of Physics at the College of St. Etienne, then at Rouen, and afterwards at the Faculté des Sciences of Montpellier. He was nominated by Napoleon III. Professor of Physics at the Lycée Bonaparte, and in 1862 became Titular Astronomer at the Paris Observatory. He was chief of the International Meteorological Service, instituted in France in 1863, and directed the publication of the *Bulletin Météorologique Mensuel*, and of the *Atlas des Orages*. In 1873, being appointed director of the Montsouris Observatory, he brought out annually an *Annuaire Météorologique*, containing a review of the work of the observatory with reference to the effect of the atmosphere on health. In 1857, Marié-Davy invented the well-known sulphate of mercury battery which bears his name, and which was largely adopted by the French Administration and elsewhere. Marié-Davy was the recipient of numerous scientific honours, and was a Chevalier of the Legion d'Honneur.

The London Papers and Late News.—It is amusing to notice from time to time how the daily papers, both London and provincial, catch at information weeks after it has appeared in the technical journals. For instance, three weeks ago we commented upon the question of the municipalisation of Glasgow telephones, and it seems that it is only within the past few days that some of our London daily contemporaries have discovered that the Glasgow Corporation have been seriously considering the subject.

NOTES.

Hospital Electric Lighting.—Enquiries are being instituted as to whether it will be more economical to light the new workhouse hospital at Patricroft (Manchester) with electricity than with gas.

The New French Warship.—In the *D'Entrecasteaux*, the new large armoured cruiser to be constructed for the French navy, the operations of revolving the turrets, serving the guns, and supplying ammunition, are to be effected by electricity.

The Idea of Electric Lighting Fort William Abolished.—According to the *Times of India*, the proposal to light Fort William by electricity, which has now been under consideration for some years, has been finally negatived for financial reasons.

The Old Method Preferred.—The Totnes Town Council have lately been considering whether it is advisable to fit up electric bells in order that the members of the fire brigade may be more speedily summoned. They have now decided that the money (£13 17s. 6d.) if expended in this manner would be almost thrown away upon an absolute superfluity. It has been resolved to adhere to the old system of ringing the church bells.

The Electric Light Accident at Leeds.—In our "Notes" last week we briefly referred to a sad accident, attended with loss of life, which occurred at the Midland Railway Company's Electric Light Installation at their Hunslet, Leeds, Goods Station, on the night of the 19th ult. It would appear that owing to a lamp calling for some attention after the current had been turned on, the chief attendant, Samuel Sykes, then in charge of the installation, proceeded to deal with it, and in doing so placed some portion of his person in contact with the circuit. A flash is said to have been observed by a bystander, while at the same instant Sykes was thrown from the ladder on which he was standing, to the ground, some 15 feet. He was immediately conveyed to the hospital where he succumbed to his injuries within three hours of the accident. The post mortem examination showed that the current had passed through his right hand, but that death was the result more of the fall than of the current, the poor fellow having sustained fracture of the spinal cord and of the skull. This accident, like so many others of its class, would appear to be the result of want of care on the part of the sufferer himself. Among the rules laid down by Mr. Langdon, the Superintendent of the Telegraph Department of the Midland Railway, is one directing that in no case is apparatus through which a current is passing, or from which it is possible to receive a shock, to be touched without the aid of India-rubber gloves; and it is a curious fact that the sufferer in this case only some few days back when sending one of his staff on duty to attend to a lamp which required attention, insisted upon his using the gloves. We can only conclude that his anxiety to remedy the defect on the occasion which was attended with such a fatal result, induced him to disregard that precaution which it is clear, from his regard for others, he felt to be necessary. The poor fellow leaves behind him a wife and three children, and his death is the more to be regretted as his superintendent speaks of him as one of the most attentive and promising men on the lighting staff. The verdict returned by the Coroner's inquest was that of "accidental death." We trust the case will bear fruit in inducing others to adopt those precautions so necessary in dealing with high currents. The E.M.F. in the present instance would not exceed 2,500 volts direct current. The circuit when tested the following morning gave an insulation resistance of over a million ohms. The lamp was, after the accident, found to be switched off. There is no doubt that Sykes sustained a shock, and that that shock caused him to lose his hold and fall to the ground. Whether he sprang from the ladder or whether it was the shock it is impossible to say, for he never recovered consciousness sufficiently to explain.

The Corinth Canal.—This canal, which was opened the other day, is probably about the only piece of work that was ever projected 2,500 years before its entire completion. Projected 600 years B.C., the work of building commenced in the reign of the Emperor Nero. By night the canal is illuminated by electricity, 70 lamps being used for the purpose.

The Highest Railway Bridge in Germany.—According to the *Engineer*, there is at present in course of construction in Germany a higher railway bridge than any previously erected in that country. It is on the line of the Solingen-Remscheid Railway. The viaduct will be double-track, 1,640 feet long and 351 feet high above the water surface, with an elliptical arch of 558 feet span in the centre. The members are to be put in place by means of a cable-hoisting system operated by electricity.

The Azores Cable.—A Reuter's telegram from Lisbon, a few days ago, stated that the new submarine cable between Lisbon and the Azores was formally opened on Saturday afternoon in the presence of the King, the members of the Royal Family, the Ministers and many other distinguished personages. A similar ceremony took place at Ponta Delgada, where the other end of the cable is situated, and was attended by the chief authorities of the Azores. Congratulatory telegrams were exchanged and a grand luncheon afterwards took place in honour of the occasion. The completion of the cable has been received in the Azores with the liveliest satisfaction.

Consulting Electrical Engineers.—The latest addition to the ranks of Consulting Engineers is Mr. Robert Hammond who is giving out that he is retiring from the contracting and manufacturing business to take up consulting work in an independent capacity. But he cannot pose as an independent consulting engineer; he is still openly connected with the manufacturing and contracting departments of four or five different companies. Only the other day at a Town Council meeting of an important town the opinion was very freely expressed that there were no independent, unbiassed, unattached, consulting engineers. Of course this is not right; there are two or three men who have not bowed the knee to Baal, and whose independence is unquestionable; but there is a good deal of foundation for the general suspicion with which engineers in the electrical profession are coming to be regarded.

American Electro-Therapeutic Association.—The following is the preliminary programme of the American Electro-Therapeutic Association, which will hold its third annual meeting in Chicago, September 12th, 13th and 14th:—Discussions: (1) "What are the Possibilities of Electricity in the Treatment of Fibroid Growths." Discussion will be opened by Dr. J. H. Kellogg, of Battle Creek, Mich. (2) "The Influence of Frequency of Interruptions and Character of Induced Current Waves upon Physiological Effect." Discussion will be opened by Prof. J. W. Morton, of New York. Several papers will be read; among them will be the following:—"The Nutritional Effects of Statical Electricity," by Prof. W. J. Morton, M.D., New York; "The Graphic Study of Electrical Currents in Relation to Therapeutics," by J. H. Kellogg, M.D., Battle Creek, Mich.; "The Action of the Continuous Current within the Living Tissues as Distinguished from the Local Polar Action," by Prof. W. J. Herdmann, M.D., Ann Arbor, Mich.; "The Therapeutic Application and the Theory of Alternating Currents," by Dr. Georges Gautier, Paris, France; "The Treatment of Fibroid Tumours with Electricity," by Dr. Georges Gautier, Paris, France; "Induction Coils," by Mr. A. E. Kennelly, of the Edison Laboratory; "Electrolysis in Tumours of the Bladder," by Robt. Newman, M.D., New York; "The Present Position of Electricity in the Treatment of Ectopic Gestation," by A. Brothers, M.D., New York; "The Use of Static Electricity in the Treatment of Incipient Insanity," by W. F. Robinson, M.D., Albany, N.Y.; "The Absorption of Fibroid Tumours by Mild Electric Currents," by R. J. Nunn, M.D., Savannah, Ga.; "Some Observations on the Fine Wire Coil for Current or Tension," by H. E. Hayd, M.D., Buffalo, N.Y.

Halifax Electric Lighting.—"Anti-monopolist," in a letter to the *Halifax Free Press*, supports the proposal of the Corporation to carry on the electric lighting business themselves; he further protests against a "so-called ratepayers' petition" in opposition to the Corporation's proposal, that was presented at the Local Government Board Enquiry last week. He insinuates that the majority of those who have signed the said petition have done so from an interested point of view, either as shareholders in the electric light company or users of the company's supply.

Electrical Quackery at Chicago.—Our New York contemporary, *Electricity*, has taken up the cudgels against electro-medical quacks and their deceptive wares. From what we understand, there is no small amount of space devoted to nostrums at the Chicago Exhibition, and *Electricity* is publishing a very full and detailed exposure of the whole thing, in order that those of the public who are gullible may be spared loss, inconvenience and annoyance, which purchasing these appliances generally entails. Our contemporary applies its criticisms chiefly in three directions—(1), to the public, that they may be on their guard against the vendors of quackery; (2), to the daily papers, to aid in the dissemination of the truth of the matter (we sincerely hope this will be accomplished, although we are doubtful); (3), to the Jury of Awards to condemn such exhibits as these. The articles which appear to be the chief offenders are electric belts, electric hair brushes, and electric headache cures. *Electricity*, like ourselves, considers the World's Fair management acted very injudiciously, as well as mistakenly, in admitting exhibitors of electrical quackery.

The Largest Search Light in the World.—Under this heading, the *Electrical World* gives a detailed description of an enormous search light recently built by the General Electric Company (New York). Our contemporary claims for the Americans the honour of constructing the largest and most powerful electric projector in the world, and publishes an illustration giving an idea of its dimensions at the side of men of ordinary height. It stands about 10 feet 6 inches high to the upper side of the ventilator on the top of the drum, and the total weight is about 6,000 lbs., but so perfectly is it mounted and balanced that a child can move it in any direction. It was built by the General Electric Company. The reflecting lens mirror used in this projector is 150 centimetres, or 60 inches in diameter. It is a concave spherical mirror of the Mangin type, free from spherical aberration, reflecting a sensibly parallel beam of light. It was manufactured in Paris especially for this projector, and is a most perfect specimen of optical work, 3¼ inches thick at the edges and $\frac{1}{16}$th of an inch thick at the centre, and weighs about 800 lbs. The metal ring in which it is mounted weighs about 750 lbs., and the total lens, ring and cover weigh about 1,600 lbs. The carbons used are also made especially for it. The upper or positive carbon is 1½ inches in diameter and 22½ inches long, with a $\frac{5}{16}$ths of an inch core of soft carbon running from end to end through its centre. The lower or negative carbon is 1¼ inches in diameter, is 15 inches long, and also has a core of soft carbon running through its centre. In addition its outer surface is heavily coated with copper. The positive carbon is set a little in front of the negative, and thus almost all the intense light of the incandescent crater is cast upon the reflector. The maximum current at which this lamp operates is 200 ampères, and at this current the lamp has a luminous intensity of about 90,000 to 100,000 candles, the reflected beam a total luminous intensity of about 375,000,000 candles, an intensity which the eye cannot appreciate. Before the projector was sent to the World's Fair, a public test was made at Middletown, Conn. How far the powerful beam of light of this instrument can be seen it is difficult to state. The search light set up by the General Electric Company on Mount Washington, in the White Mountains, has a diameter of only 30 inches, and a reflected light from the mirror of about 100,000 C.P., yet a newspaper can be read in its beam 10 miles away, and the light can be seen from points 100 miles away. How much farther, then, could this 375,000,000 C.P. light be seen in a clear atmosphere free from moisture, if the projector could be mounted upon an eminence sufficiently high to clear all surrounding obstacles?

Chronology.—An interesting chronology of electricity, galvanism, magnetism and telegraphy is now appearing in the pages of *La Lumière Electrique.*

The Congress at Chicago.—The last number of the New York *Engineering and Mining Journal* to hand contains the following paragraph: — "As the time (August 21st) approaches for the assembling of the World's Congress of Electricians, the following items may be of interest. It will be remembered that at the meeting of the Advisory Council, held January 17th last, several committees were appointed, and among others a committee to decide upon the number of members that each foreign country should be invited to send to sit in the Chamber of Delegates. Their apportionment was as follows :—Five each for England, France, Germany, Austro-Hungary and the United States; three each for Belgium, Italy and Switzerland; two each for Norway and Sweden, Holland, Denmark, Russia and Spain; one each for Portugal, British North America, Australian Colonies, India, Japan, China, Mexico, Brazil, Chili, Peru and the Argentine Republic, making 55 in all. Up to the present moment eight of the more important countries have officially responded to the call. In addition, about a thousand invitations in all have been sent out, and from the number of acceptances that are coming in there is every reason to believe that the Congress will be well attended."

In Dixie's Land.—In the August number of our Atalanta contemporary, *Dixie*, is an article evidently from the pen of the electrical editor, Mr. Francis W. Willcox, which contains a strong discourse in defence of central station experts, whose advice, he observes, is sometimes ridiculed, and their assertions, which are generally put forward after lengthy practice and experience, often completely ignored by members of some municipal bodies. This inconsistent and bigoted procedure on the part of such authorities is designated by our contemporary "electrical ignorance." Whether ignorance, thoughtlessness, prejudice, or assumed dignity is the cause, it is undoubtedly unwise to set aside the recommendations of an individual who has been engaged for the benefit of his advice in operating and effecting improvements in the working of a station. *Dixie* cites a special instance of such treatment, under the inspiration of which it is evident the article is written. A town not far from Atalanta, owning and operating its own electric plant, secured a few months since the services of a very competent electrical superintendent, who was thoroughly familiar with all the detailed working of electric lighting stations. Upon commencing his duties he discovered that the station had been but poorly managed by his predecessor, and that many alterations and improvements were necessary to render it more efficient as well as economical. After remedying as many of the smaller defects as were practicable without much expense, he found that the grate area of the boilers was so large as to result in an unnecessary waste of fuel. He applied to the authorities for permission to reduce the size and thus effect an economy, but was met with a decided refusal. Further, he advised the distribution of meters among the consumers, and demonstrated the benefits to be derived therefrom, but after discussing the matter it was decided not to adopt this proposition either. *Dixie* makes some remarks regarding the ignorance of town councillors and similar functionaries in the matter of electric lighting, and their incompetency to decide such important questions. An instance of this is shown in the following extract from our contemporary's remarks :—"One of the councilmen made the absurd statement that it did not make any difference whether one light or all the lights were burning, as it took the same amount of power to run the station, no lights or all the lights. The superintendent endeavoured to explain the error of this statement, but the council took the side of their ignorant member, and in their consummate prejudice, impudence and ignorance, refused to believe the expert statements taken from the positive knowledge and actual experience of the superintendent. . . . All such councils and boards of directors should learn to trust their superintendent, to believe in him and aid him. If a superintendent is worthy of being trusted at all, he is worthy of being fully trusted. A station gains nothing and has everything to lose when its managing council opposes and antagonises its superintendent, instead of aiding and encouraging him."

Southampton and Overhead Wires.—The Board of Guardians have refused their consent to an application for permission to erect telephone poles in the girl's school yard and the North Road.

East Coast of Central America Cables.—The Central and South American Telegraph Company are about to lay cables from Salina Cruz to San José (Guatemala), and from San José to La Libertad. A telegraph office has been opened at San José.

Transformer Test.—M. Claude, in our contemporary, *L'Industrie Electrique*, resuscitates the method of calorimetrically measuring the loss of energy in transformers. The method employed is old, namely to find the steady current energy required to keep up the temperature difference of the transformer and the air to the same amount as it actually is working at various outputs. The objects are those that have been raised before, namely the length of time required, the necessity of a room at constant temperature, and the varying conditions of the alternate and direct current heatings. M. Claude, however, claims to have got results agreeing closely with Dr. Flemings.

Taunton Electric Lighting.—After many delays, and controversial questions arising between the local councillors entailing the usual differences of opinion and heated discussions, the municipal electric lighting of Taunton may now be considered a settled matter. Considerably more than 12 months ago the public purchase of the electric light works from the Taunton Electric Lighting Company was first brought under the consideration of the authorities. Many unpleasant difficulties of one kind and another were encountered alike by the company and the council. The ratepayers, as well as the local gas company, memorialised the Board of Trade to refuse the council the powers for which they were applying. Application to borrow the necessary money was made by the authorities to the Local Government Board, and twice the representative of the last-mentioned body journeyed to Taunton and held enquiries. Sanction was in due course granted for borrowing £15,000, as stated in the ELECTRICAL REVIEW of August 18th, and it has now been resolved that the purchase of the works by the council be completed by September 30th. Dr. Fleming has been appointed consulting engineer for one year, and Mr. H. E. Hunt has been retained as electrical engineer at £150 per annum.

Glasgow Telephones.—We recently gave some particulars regarding the proposed municipalisation of the Glasgow telephone service. We stated that application was to be made to the Postmaster General for a license. This we understand was accordingly presented, and in response the Postmaster General has observed that the application refers to a recommendation of the recent Joint Committee on electric powers. He also considers it befitting that he should inform them that he has received a communication on the subject from the Association of Municipal Corporations. The question whether measures shall be taken, and, if so, what measures to give effect to this recommendation of the Joint Committee must, he says, engage the very careful consideration of her Majesty's Government; and the Association has been informed that no final step will be taken until they have been afforded an opportunity of expressing their views. In view of the intimate relation between the question of fresh licenses for Telephone Exchange business and that of Statutory powers for laying telephone wires underground, the Postmaster General does not feel that he can at present arrive at any decision on the application from Glasgow.

The Postmaster-General received a deputation on Wednesday at the House of Commons, introduced by Sir Charles Cameron, M.P., from the Glasgow Town Council, which asked, on behalf of the Glasgow Corporation, to be allowed a license to start a Municipal Telephone Exchange. In reply, the Postmaster-General said he would not interfere with the freedom of municipal enterprise in any direction, but at present he was engaged in purchasing the trunk lines of the telephone system, and until that was completed it was impossible to consider the question raised by the present application. The movement he added might possibly develop into the Government taking over the entire management.

Correction.—In our review of Messrs. Haeder and Powles "Handbook on the Steam Engine" last week, several typographical errors occurred. Paragraph 3, line 12, should read "Zeuner" not "Zenner." Par. 3, line 13, read "such *link* motion" not "such *like* motion." Also in par. 1, line 10, read "*of* engines by well known," &c.

Lighthouse Illumination.—Some of the provincial dailies have, within the last few days, published remarks and opinions of a number of shipmasters and others, regarding the unsuitability of electricity as a lighthouse illuminant. The opinions are generally condemnatory of the new light for use under hazy conditions of the weather, and mariners would rather be without it.

Coast Communication.—A Canterbury correspondent of the *Daily Telegraph* states that arrangements are being made for the establishment of communication between the Kentish Knock Lightship and the Kingsgate Coastguard Station, which will then be connected by telephone with the telegraph office at Broadstairs, so that telegrams can be sent for the Ramsgate or Harwich tugs if required, as soon as any vessel is seen in distress by the crew of the lightship.

Advertisements.—We would like to say just a word on the subject of advertisements charging competitors with making false statements. The effect on an outsider who buys an electrical paper, and finds on its front page a couple of advertisements of this character, must be to induce a feeling of sadness at the evident low standard of commercial morality prevailing in the electrical trades. Such a person (the much-courted Town Councillor, for example) cannot be expected to know who is to be depended upon. We evidently require a censor of good taste in electrical advertisements.

The Post Office and the Telephones.—In the House of Commons last Friday, the Postmaster-General, answering Mr. Maclure, said a draft of the agreement between the Post Office and the National Telephone Company was now under consideration, and he hoped there would be no undue delay in concluding the matter. In reply to Captain Bagot, he said that when the telephone trunk lines came under the entire control of the Post Office, as they would do under the existing scheme, there would be no favour or priority in their use given to any particular person.

A Strike.—Of late years, when dissatisfaction arises among workmen, or there is any trivial cause for complaint between themselves and their employers, and the latter express their inability to grant all the concessions desired, the first suggestion to the men's minds as the most effective method for remedying their grievances, is to assemble together, democratically discuss and enlarge their bone of contention, and ultimately resolve to strike. It is needless here to consider whether such steps are advantageous or otherwise to the men who strike; but there is little doubt that the disastrous effects in other ways are very numerous. The dearness of coal at the moment, owing to the action of the miners, will by no means assist in effecting economy in central stations, where the efforts of engineers and others are concentrated upon reducing the cost of coal consumption and thereby bringing down working expenses and increasing profits. The men engaged upon the construction of Richmond Electric Lighting Station have followed the footsteps of the miners and struck work. About 50 men were engaged upon the work when the engineer to Messrs. Latimer Clark, Muirhead, & Co., for some reason or other of his own, dismissed three of the workmen without reference to the foreman, who claimed that this was his province when he saw it necessary. The men sided with their foreman and left the works in a body. In subsequent communications the firm refused to comply with the demands of the men for the reinstatement of their colleagues and payment as if the work had gone on. The strike so far has not interfered with the laying of the mains. We understand that the men returned to their work on Tuesday morning last. From what we know of the conditions it seems that the firm have acted wisely in refusing to concede all or any of the terms demanded by the men. All of them, with the exception of the three labourers and the foreman who had resigned, were taken on by a new foreman unconditionally.

The Parisian Inventors' Academy.—This honourable society which some time ago conferred gilded medals at a low cost upon English inventors is now considering the claims of American patentees.

Dewsbury Electric Lighting.—A Local Government Inquiry was held on Tuesday *re* the application of the Corporation, to expend £25,000 on a scheme of electric lighting. There was no opposition.

Bolton Electric Lighting.—A Local Government Board Enquiry was held last week regarding the application of the Corporation for power to borrow £40,000 for electric lighting purposes. There was no opposition. Street electric lighting is not at present contemplated. The outlay involved at the moment amounts to £21,000, but the question of probable extensions had to be borne in mind.

Elmore.—The following communication has been sent us by Mr. J. A. White, residing at 41, Beatrice Road, London, S.E., regarding a paragraph in our "Business Notices" last week:—"With reference to your reprint from the *Financial Times*, in your last issue, relative to an alleged scandalous affair in connection with the Elmore group, I beg to say that the case referred to is just one of those many mare's nests that abound in the paths of the Elmore critics. The cash subscribed a short time ago for debentures of the French Elmore Company is still intact in a distinct account at the bank at interest, and will be returned in full at the earliest possible moment to the subscribers, inasmuch as the debentures were never allotted; but this can only be done by order of the Court, in pursuance of the voluntary liquidation into which the company went in May last, with a view to reconstruction. The business has been sold to a strong company in France, and the cash part of the sale price has been received. However, the old company cannot be wound up piecemeal, but as soon as the creditors are dealt with, and the balance of the assets handed over to the shareholders, the moneys subscribed for debentures will be returned to the subscribers."

CONTRACTS OPEN AND CLOSED.

OPEN.

Storrington (Sussex).—September 8th. The Lighting Inspectors require tenders for street lighting (35 lamps), for lighting season commencing on October 1st.

CLOSED.

St. Pancras.—The St. Pancras Vestry have accepted the tender of Messrs. Johnson & Phillips for their "D. P." accumulators for the extension of the Regent's Park Central Station.

BUSINESS NOTICES, &c.

J. A. Berly's Universal Electrical Directory for 1893 (12th year), 784 pp. This standard work, now under the direct supervision of the proprietors, H. Alabaster, Gatehouse and Co., contains a larger amount of trade information than any other similar publication, and should be in the hands of every engineer and electrician. Free within the Postal Union for 4s.

Windsor and the Electric Light.—Mr. A. E. Farrow writes to the *Windsor Gazette* a somewhat lengthy letter containing some proposals regarding the electric lighting of the town. He says the provisional order granted to the Windsor and Eton Electric Light Company, embraced too large a district to prove remunerative to its shareholders, and, had the company laid mains all over the area, which the provisional order included, Windsor would be in the unenviable position of having by far the least number of lamps per mile of main than any supply company in existence. Datchet, which is included in the order, is too far from Windsor, and the demand for electric light is also too small to prove in any way remunerative. . . . . Regarding the supply, the best system of electric light to adopt in Windsor would be the low-tension three-wire system; as the consumers are all within a half-mile radius of the supply station (assuming, of course, that the new works will be where the old ones are). The station ought to be built to be able to contain enough machinery for 9,000 lamps, and equipped with the necessary engines and boilers for 3,500 lamps, which there is an immediate demand for. The additional machinery could be installed as required. The approximate cost of building the above, with all necessary boilers, engines, dynamos, accumulators, &c., for 3,500 lights of 8 C.P., would be about £9,000. To lay down mains from supply works to Peascod Street, along up Peascod Street to High Street, down Peascod Street to Osborne road, to extend along High Street to the lower end of

Frances Road viâ Sheet Street, also down Thames Street to Windsor Bridge, they should be laid with enough copper to carry 9,000 lamps, and should also have necessary feeders to keep the pressure, as near as possible, constant. These would form the principal mains, and less expensive ones could be laid in the side streets, whenever required. The cost of mains, including the laying down in the above streets, would be about £4,000. Thus, with the purchase of land, law and incidental expenses, the cost would be about £14,000. As to the income to be derived from the sale of electricity, of course the first year the station would only about pay its expenses; but, it is certain, that in the second year there would be quite 3,500 lamps on. Now, a fair average consumption of electricity for an 8 C.P. lamp per year is 25 units, so that 3,500 lamps, taking 25 units each per year at 8d. per unit, means £3,750; the cost of the works would be about 4¼d. per unit; there would, therefore, be a saving or profit of £1,693."

Catalogues.—The electric light fittings trade is fast becoming a gigantic industry in itself. As the demand for electric lighting increases, so must the business done in electrical fittings necessarily progress. An index to this fact, undoubtedly lies in the number of exquisite and elaborately illustrated catalogues or albums that have lately been brought before the attention of the public. The latest addition to the list is that of Messrs. Richard Crittall and Company of Manchester Square, W. This splendid work—for its excellence warrants such expression—with the exception of a prefatory note by the publishers, is entirely composed of illustrations very neatly executed and printed. These illustrations show a variety of artistic covers for electric light switches and cut-outs, as well as numerous ornamental patterns of door furniture. Assuming the relief in the articles themselves to be as clear and pretty as in the blocks, they are exceedingly well done. Altogether, there are twelve full-page plates and a supplementary list, giving many details and prices of the fittings described in the plates.

The Leeds and London Electrical Engineering Company have lately published a very good catalogue descriptive of the "Lowrie-Hall" system of electric lighting, and the manufactures of the firm generally. It has been neatly set out, cleanly printed, and nicely bound in the new form of convenient covers to allow of extra sheets being interleaved. The printing has been executed with a tasteful mixture of colours, and the illustrations, on the whole, are very well done. A note at the commencement of the book, announces that the company have lately secured the services of Mr. C. J. Hall, M.I.E.E. The following are some of the articles particularised in the book:—Electric converters, converter cases, small station converters, station main fuses, converter fuses, high pressure fuses, station main and other switches, hand regulators, synchronising bases, &c., fault detectors, &c., &c.

The North British Wire Manufacturing Company have sent us a copy of their list of dynamo brushes, with prices and particulars of all the various sizes of brushes.

Bristol Exhibition.—An industrial and fine art exhibition was opened at Bristol on Monday and will be continued for some months. A special building has been erected for the purpose, and as the exhibits are varied and fairly representative of local industries, the collection is of a popular character and likely to prove attractive. The general lighting of the building is done from the new City electric lighting station, both arc and incandescent lamps being used. Many of the stalls are lighted by Messrs. King, Mendham & Co., who run a Taunton dynamo for the purpose. This firm also exhibit electric heating and cooking apparatus. In the art section of the building which forms a concert hall, there is an ornamental fountain which is illuminated in colours by means of high power incandescent lamps, by Messrs. F. W. Ball & Co., a firm of electrical engineers recently started in business at Bristol. The Brush Electrical Engineering Co. are represented by L. Alwyn, Limited, who are also the Bristol agents for the Premier gas engine of Messrs. Wells Bros. Messrs. Ernest Scott & Mountain also have a show of dynamos, motors, search lights and ventilating fans. The best show of electric light fittings in brass and wrought-iron, is made by Messrs. T. Harris & Son of Wine Street, Bristol. Another good display is made by Messrs. J. S. Willway & Sons, also of Bristol. Messrs. Price, Sons, & Co., exhibit their highly glazed battery jars, porous cells, stoneware and porcelain—stoneware insulators; Sampson & Co. of Stroud, machine belting; United Asbestos Co., samples of their manufactures; and Osler & Co., electroliers, and other fittings in cut glass. Two very interesting processes connected with local industries are shown in operation, namely, that by which polished slate is marked in imitation of marble (by Messrs. Arthur Lee & Bros.), and the way in which the well-known "Three Castles" tobacco is made up into two-ounce packets by an ingenious machine fed with wrappers and contents by six or seven girls.

Kelvinside Electric Light Station.—On the invitation of the directors of the Kelvinside Electricity Company, Limited, a number of gentlemen were, on Monday afternoon last, afforded a special view of the new electric supply station at Hughenden Road, Kelvinside. The Kelvinside Electricity Company, it may be mentioned, was formed some three years ago, with a view of providing an electric supply for the whole of the west Kelvinside district, including Dowanhill. Operations for the establishment of a station were begun little more than twelve months ago, and have now been completed. Here there are two electric generators each of 150 H.P. Each machine is capable of producing 3,000 eight candle-power lights, making 6,000 in all. The battery room contains no less than 60 accumulators of the largest type capable of a maximum discharge of 1,200 ampères. Messrs. Sharp & Kent, Westminster, were the sole contractors of the work which has been carried out with entire satisfaction. Messrs. Anderson & Munro of Glasgow, were the consulting engineers. The cost of the undertaking will be about £17,000.

Elmore.—A correspondent of that financial contemporary whose motto is "Without fear or favour," harps afresh with discordant sound on that fast decaying string "Elmore." This time the Foreign and Colonial Company are the offenders, and they are brought to book by the writer, who, it appears, would be much gratified could he compel the directors of the concern to redeem their public guarantees to the preference shareholders. He says:—"Can nothing be done to make the Elmore Foreign and Colonial Company redeem its public guarantee to the preference shareholders, and pay the first year's interest of 10 per cent. They paid the first half on November last? The second half was due on May 1st. No more has been paid. I parted with my £100 upon the direct representation of the company that they would pay the first year certain, and even this, with the usual consistency and truth that characterise all their statements, they represented would not be required of them, as the French Company would have almost unlimited means to pay all demands out of profits without calling upon them. Now, Sir, when you apply to the company they try to shift their obligation upon the new French Company 'who, by the way, I should like to hear something about,' and say they are pleased to say that with the new company provision has been made for the outstanding dividend due. I trust that some shareholders will bestir themselves and, through your columns, bring these shuffling defaulters with their false statements and promises to account."

The Electric Light at Scarborough.—The Scarborough Electric Supply Company, Limited, commenced the supply of electricity in Scarborough on Saturday last. As yet, the current is only available in a portion of the town, but the remaining connections are being completed as fast as possible, and it is expected that in the course of a week or two, the whole of the mains will be in operation. The company was formed at the end of last year by A. A. C. Swinton, by agreement with the Corporation of Scarborough, and is working under a transfer of the provisional order obtained by the Corporation. The alternate current high tension system, with low tension distribution from sub-stations, is employed. The charge for electricity is at the rate of 7d. per Board of Trade unit, with a cash discount and a sliding scale rebate amounting to 20 per cent. as a maximum for large consumers. Colonel R. F. Steble is chairman, and Mr. A. A. C. Swinton managing director and chief engineer to the company. The whole of the electric generating plant and transformers have been supplied by Messrs. C. A. Parsons & Co., of Heaton Works, Newcastle-on-Tyne.

Farrow v. White.—The other day at Chelmsford County Court, Henry Farrow, plumber, &c., sued Ernest W. White, bookbinder, for 14s., the price of a portable electric bell supplied. Mr. Walter Farrow said the bell was supplied and not fixed by his father. It was a perfectly new bell. The defendant said he had a man who could fix it, and he wanted to give him the job.—The defendant said the bell would not work, and he sent it back to the plaintiff, but he would not take it in. Witness's brother-in-law fixed the bell.—George Wood, employed at the Arc Works, said he was called in to see the bell. There was nothing the matter with the bell, but the battery was wrong; it was a "waster." He would not like to give more than 2s. for the whole concern.—His Honour gave judgment for the plaintiff for 10s. 6d., without costs.

It would be highly interesting to know what kind of battery Mr. Crompton's employé terms a "waster," and also how he estimates 2s. as being too high a price for bell and battery combined.

The London Battery Company, Limited.—Notification as follows is promulgated in the *London Gazette*:—"Creditors are requested, on or before October 17th, 1893, to send their names and addresses, and the particulars of their debts or claims, and the names and addresses of their solicitors (if any), to Henry George Ellis, 1 and 2, Marlborough Street, Great Charlotte Street, Blackfriars, S.E., the Liquidator of the said Company, and, if so required, by notice in writing from the said Liquidator, are, by their solicitors or personally, to come in and prove their said debts or claims at such time and place as shall be specified in such notice, or in default thereof they will be excluded from the benefit of any distribution made before such debts are proved."

Sykes's Improved Fuel Economiser Co., Limited.—The *London Gazette* publishes notification that a petition of Thomas J. Till and Frederick Whitehead (creditors of the company), for winding up the company, directed to be heard at Lancaster on August 24th, was adjourned by the Court and will be heard on September 7th, before the Court sitting at the Chancery Office, 9, Cook Street, Liverpool, at 11 a.m., when the Court will be asked to make an order continuing the voluntary winding up of the company under the supervision of the Court, instead of making an order for the winding up of the company by the Court. Creditors or contributories desirous either of supporting or opposing the said petition, must appear or be represented at the hearing.

Gas v. Electricity at Bristol.—Shareholders in the Bristol Gas Company, like shareholders in all gas companies, are fearful of the effect of electric lighting upon their revenues in the near future. The chairman of the Bristol Company, at the half-yearly meeting, last week, told the shareholders that he thought the present power of corporations of carrying on lighting by electricity at the cost of the ratepayers was not fair to the gas companies, who were probably the largest ratepayers; but as they had to put up with it they must do so as cheerfully as they could.

Electric Fire Alarms.—Cleckheaton Local Board have resolved to invite tenders for the fixing of electric alarm bells in the houses of all the members of the fire brigade.

Personal.—Mr. Robert Hammond has been appointed consulting electrical engineer to the Corporations of Newport, Mon., and Wakefield, to carry out the electric lighting work under the provisional order.

Mr. Vincent Swindells, who has been connected with the New Telephone Company at Manchester, and with its predecessor, the Mutual Company, from its foundation, has been presented with a handsome testimonial by his late colleagues, upon the occasion of his resignation. We understand that Mr. Swindells has accepted the representation of the Fowler-Waring Cable Company in the North of England.

J. H. Holmes & Co.—This firm have obtained the contract to light throughout by electricity the newly erected Prudential Assurance Buildings, at the corner of Mosley Street and Dean Street, Newcastle-on-Tyne. The installation, which will be a very complete one, will have a total of 400 lights. The firm have also obtained the contract for an electric lighting installation in the Wallsend and Hebburn Collieries, and have many other contracts for land and steamship installations in progress.

Austin & Myers.—At the offices of the Leeds Official Receiver in Bankruptcy last week, a meeting was held of the creditors of Harry Austin and James Myers, trading as "Austin and Myers," manufacturing electricians and electrical engineers, Armley. The joint liabilities were stated to be £261 18s. 11d., and assets £79 4s. 6d. No resolution was passed at the meeting.

Electric Light at Falmouth.—Mr. J. Grose, ex-mayor of Falmouth, is re-building his premises, and has made arrangements with Messrs. Veale, Limited, St. Austell, for an installation of electric light, which will also serve for his extensive shops opposite Messrs. J. Grose & Son. This will be the first introduction of electric lighting for commercial purposes in Falmouth. The Polytechnic Hall will also be lighted by electricity during the forthcoming exhibition.

Sale by Auction.—On 7th inst., Messrs. Wheatley Kirk, Price & Goulty will sell by auction the entire contents of the works and showrooms of Fawkner, Rogers & Co., at 11 and 12, New Bridge Street, Ludgate Circus, London, E.C.—The same firm will also sell by auction, on 14th and 15th insts., the plant and machinery, &c., of the Northern Telegraph Works, Square Road, Halifax. Full particulars will be found among our advertisements.

Canterbury Electric Lighting.—An official intimation was recently received by the Mayor, that the Brush Electric Engineering Company had accepted the agreement for the transfer of the electric lighting provisional order for Canterbury as revised by the Board of Trade. It only remains, therefore, says the *Kent Herald*, for the installation to be proceeded with.

City Mains.—At the last meeting of the City of London Union the Thavies Inn Committee reported that they had resolved to leave the matter of the electric lighting tubes found under the paving near the walls next Robin Hood Court in the hands of Mr. W. M. Cross and Mr. Boyle, with power to confer with the clerk and architect thereon.

Watford and Electric Lighting.—Some time ago Watford decided to apply for a provisional order. A question was asked at a recent meeting of the Local Board as to whether anything had been done in the matter. The only reply forthcoming was that the question was receiving attention.

Harrogate Electric Lighting.—The Corporation have resolved, by thirteen votes to seven, to undertake the lighting of the town themselves. We referred to the recommendations of the Electric Lighting Committee, which have now been adopted, in our issue for August 18th.

Corlett Electrical Engineering Company, Limited. This company have secured the contract for supplying and erecting a large pumping plant for the Consett Iron Company, Limited. It will consist of a three-throw ram pump driven by an electric motor, and two centrifugal pumps, each coupled direct to an electric motor.

International Electric Syndicate, Limited.—According to the *London Gazette* of Tuesday last, the first meeting of contributories is to be held at 12 noon, on September 13th, at 33, Carey Street, Lincoln's Inn, W.C.

Kingston Electric Lighting.—Satisfactory progress is now being made with the electric light works, and the Corporation have intimated that they expect to be in a position to commence the supply early in October.

Stirling and Electric Lighting.—The Caledonian Electric Supply Company, Limited, have notified the Council of their intention to apply for a provisional order. The matter is under consideration of a committee.

Telegraphic Communication.—The Eastern Telegraph Company, Limited, announces the connection by submarine telegraph cable of the Islands of the Azores with Lisbon and the general system of cables.

Russell & Co.—This firm informs us that they have taken over the contracting business hitherto carried on by Mr. Medhurst at Cambridge, and have work in progress at several of the colleges. Their local office is 6, St. Andrew's Street, Cambridge.

Electric Lighting at Powderhall Refuse Works.—The Lord Provost has decided to turn on the electric lighting at these works on September 11th.

Electric Carbons.—A contemporary states that it is calculated that about 200,000,000 carbon pencils are now used every year in the United States, and investments in carbon amount to £300,000.

Direct Spanish Telegraph Company, Limited.—We are informed that direct cable communication with Spain, viâ Bilbao, was restored at the end of last week.

National Telephone Company.—A call of 25 per cent. on issue of £273,523 four and a half per cent. debenture stock, was due yesterday.

Private Installation.—Wm. Ramsay & Co., of Argyll Street, Glasgow, have lately secured the first electric lighting contract in Berwick. It is to be a complete installation.

CITY NOTES, REPORTS, MEETINGS, &c.

Brush Electrical Engineering Company.

THE fourth annual general meeting of the shareholders of the Brush Electrical Engineering Company, Limited, was held on Thursday last week, at Cannon Street Hotel, E.C., Mr. J. B. Braithwaite (the chairman) presiding.

The SECRETARY (Mr. B. Broadhurst) having read the notice convening the meeting,

The CHAIRMAN, before moving the adoption of the report, alluded to the great loss which the company had sustained by the death of the Duke of Marlborough, the late chairman of the company, and to the withdrawal of their managing director (Mr. Garcke) to join the fortunes of the Electrical Construction Corporation. Turning to the balance-sheet, there were one or two items to which he ought to call their attention. They would observe that they had issued during the past year a certain amount of additional capital, as was foreshadowed at their meeting last year. The increase of their business had been so steady and so persistent, that they had found it necessary once more to enlarge the capacity of their works at Loughborough. During the year they had erected three additional shops there, and now the works' manager was crying out for more accommodation owing to the increase in their contracts; but they were careful not to make any extension to meet the sudden rush of business unless they had ground for believing that the extension would be needed for the permanent business of the company in future years. They would see that they spent during the year £10,681 in adding to their plant and buildings at Loughborough. They had issued 15,000 new preference shares and 10,000 additional ordinary shares. On those they were fortunate in obtaining a premium, which they would see on the other side of the balance-sheet. They received a balance of £3,150 on the issue of those shares, the whole of which were taken up and subscribed for. That, he thought, in itself was as solid a testimony to the standing of the company, and the view which was taken of its prospects by the investing public, as they could have. The debenture stock, which stood last year at £111,347, had now been raised to the full figure of £125,000, which was the total amount of debenture stock authorised. Coming to the item of creditors, they would see a considerable change between their present position and their position that time last year. They now owed £41,000, but last year they owed £59,624 to creditors and £19,000 on bills payable, making a total of £78,000. They would, therefore, see that they owed £37,000 less than they did that time last year, which was a satisfactory position, especially when it was supplemented by the fact that, on the other side, they were owed £119,540, as compared with £105,000 that time last year; so that they were owed £14,000 more and they owed £37,000 less. Their contingent liability in respect of uncalled capital, on shares in other companies, on guarantee, and on bills receivable discounted, had been reduced by about £3,300 during the year, and now only amounted to £9,420. Last year it amounted to £12,700. That again, was a favourable feature. On the credit side there was an increase in the item which they called stock. If that had been obtained in order to keep their works running and to stock their warehouses he would object to the increase of that item; but as the whole of that increase represented additional work which they had in hand, for which they had received orders, he was very glad to see the increase. The item of goods in hand and in process of manufacture last year stood at £77,990, but it now stood at £91,555; therefore, there was an increase in the work they had in hand for customers of between £11,000 and £12,000. Their cash in hand had increased by £2,000 or £3,000. The shares and debentures in other companies remained at almost the same figure. The preliminary expenses were written off £800 last year; they now figured at £1,575, and, if they approved of the directors' recommendation, the whole of that amount would be written off out of the year's profit. The liquidator's balances stood at the same figure as last year, while the balance of foreign and colonial branches was £61,492, instead of £82,737. The great bulk of the difference there shown was owing to the sale of their station at Temesvar. Turning to the appropriation account, they would see that they proposed, out of the available balance of £15,894, to pay dividends on the ordinary shares at the rate of 7 per cent., and at the rate of 6 per cent. on the preference shares for the half-year, absorbing £13,514. They proposed to write off the whole of the preliminary expenses, amounting to £1,575, and to carry forward a balance of £815, which was considerably more than they carried forward last year. Turning to the profit and loss account, there was a slight decrease in the standing charges. At the last meeting they stated that the concentration of

the company's works would doubtless lead to considerable economies, and they still held that view. Owing to the extreme pressure of business, and the necessity of enlarging the works, they had only completed the concentration within the last two months, and even now the last extension was not quite finished; so that they were hardly at present settled down in their new quarters. Very little economy could be expected under that head in the accounts of the past year; but, in spite of that, the standing charges were £17,427, as compared with £20,055. Deducting from last year's item the special amount of £2,000 for the exhibition at the Crystal Palace, it showed that the standing charges were about £600 down during the year, notwithstanding the increased volume of business. During the current year, the board anticipated that the economies effected by concentrating all the manufactures at Loughborough would be apparent, and they hoped to see the figures materially reduced. A special item of expense had been the cost of removal to Loughborough, which stood at £1,328. The shareholders would agree that this was a very reasonable expenditure, in view of the great importance to the company of concentrating the works in such a favourable position for manufacture. This was an item which might be properly spread over a period of years; but the board now recommended that the whole of it should be written off out of the profits of the past year, so as to leave a perfectly clear field in the future for the distribution of the profits. During the past year £2,368 had been spent on maintenance of buildings and plant, and £138 on the maintenance of patents. Interest on debenture stock was rather more than last year, owing to the full amount being issued, and the balance of net profit was £26,394. On the other side there was the item of premiums on new issue of shares and debentures; and the gross profit, which on this occasion did not include the profits of the Austrian and colonial business, amounted to £49,405. Those who understood balance-sheets would see that, if last year's balance-sheet was sound, this year's was sounder, and by writing off the two remaining items which blocked the way to increased dividends, viz., the preliminary expenses and the cost of removal to Loughborough, every item had been eliminated from the balance-sheet which could possibly prevent the distribution of the profits they might make, with due regard to reserve and other contingencies. It was a great satisfaction, also, to feel that the past year's business had been so good that, in spite of the paralysis of business in Australia and the drawbacks they had experienced in their Austrian business, they had been able to show a profit of practically £50,000 on their English operations. As to orders, the company was in a very satisfactory position. The shops were absolutely full of them—so much so, that the only question was whether they could take more for delivery within the time specified. The company constantly employed about 1,300 men in its works in England and Austria. They had orders in hand at the present time which practically enabled them to see their way to full work until this time next year, and business continued to come in at a satisfactory rate. Although their shops were full of orders for their present manufactures, and although they appeared to command the confidence of those who required electrical plant and machinery, it was necessary to keep their eyes open for new developments, as the industry had by no means attained to its final stage. During the year they had had three items in that direction which would be of interest to the shareholders. The first was the completion of the large machines they had been building for the City of London Company. As he explained last year, they had undertaken to supply the City of London Company with alternating current dynamos of 400 kilowatts, which were four times larger than any they had previously made. Last year he told the shareholders that they had reached the half-way house with the machines they were building, and now the 400 kilowatts machine had turned out even more satisfactory than that of 200 kilowatts. They had had experience in the City of London within recent times of the demand for current being quadrupled, and even increased five or six fold, within the space of 20 minutes; therefore, if the supply companies had not such machines, they would find themselves in difficulties on the advent of any sudden fog or heavy shower of rain. So far, however, the machines had been able to meet the demands, and enable them to supply their customers without any hitch or difficulty. What they were supplying for the City of London Company was an alternating current machine. During the past year they had obtained the sole rights for England for the manufacture of Desrozier's direct-current machine. They would shortly have these machines on the market, and he had little doubt they would do a large business with them. They had also made arrangements with the Otis Lift Company to supply the lifts for hotels and other places, and were now manufacturing these in England. This suited them well, and came in handy with the building of their cars. In view of the large number of supply companies now putting down mains in London, it seemed likely that a good many lifts would be worked by electricity. The directors had considered it prudent to make this arrangement in order to have two strings to their bow in the wood-working shop, as they had two strings to their bow in the electrical shops. As to the foreign business in Australia, the complete collapse had, naturally, brought matters almost to a standstill; but it was satisfactory to be able to say that the company had not been a loser through the failure of any of the Australian banks. The business was intact there, and they were beginning to receive remittances, showing that the business was on a sound basis. Owing to the practical stoppage of the business during the past year, it had yielded no revenue, and the figure in the balance-sheet had been virtually earned by the British business. In Austria the profits had suffered a large diminution, owing to the competition in glow lamps. They had, however, made arrangements in connection with the Austrian business by which they would be able to do more in the way of installation works and building dynamos, so that the glow lamp branch would not be relatively so important. As to the general outlook for the future, the electrical industry was by no means fully fledged in this country. A good deal had been done in the direction of electric lighting; but up to this time little or nothing had been done in the way of electrical traction. It seemed, however, as if some progress would be made in this direction. The opening of the Liverpool overhead railway and the line from the Monument to Stockwell in London, with the successful working of one or two tram lines seemed to show that the day was not far off when electrical traction would become an important branch of their business. They were favourably placed for dealing with any work of the kind, as they could not only build the engines and motors, but also the cars themselves at the Falcon Works. When electrical traction, therefore, came to have a permanent place in the electrical engineering business the Brush Company would, no doubt, have its fair share of the work. With regard to electric supply stations, a great deal of progress had been made in this country, and especially by municipalities, 108 of which had secured electric lighting powers. Of these, 28 were applying for powers to borrow money in order to carry out their works, while 17 had already received permission to do so, and had stations in course of erection. In orders for these the Brush Company had done fairly well. Huddersfield station had been fitted by them, and they had work in hand for other municipalities. The station at Lancaster was a continuous-current station, while the others were to be supplied on the alternating-current system. The company had also a considerable amount of work in hand for private companies. They had fitted up stations of this kind at Coatbridge, Sheffield, Bournemouth, and other places, and expected soon to commence work at Dover and Canterbury; in fact they were getting a fair share of this business. With regard to the general business, he did not think it was necessary for him to go into details of the smaller orders they obtained for private installations. As they were aware, the cost of electric lighting was increased by the price of the lamps, for each of which 3s. 9d. had to be paid; but when the Edison patents expired the cost of those lamps would be reduced to 1s. 6d., which was less than half the price they were now paying for them. When the reduction of over 50 per cent. in the price of lamps took place, many people who had hitherto held back would adopt the light, and that should give an impetus to the electric supply. When the expiration of that patent took place they would be in a position to resume the sale of their lamps, which was stopped by the Edison and Swan Company's action. After November 10th, when that patent expired, they would be in a position to supply their customers with everything complete—from dynamos to lamps. He concluded by moving, "That the report of the directors and statement of accounts to June 30th, 1893, now presented to the shareholders, be received, and that the same be hereby adopted."

Mr. B. H. VAN TROMP seconded the resolution, which, after a few remarks from Mr. SMART and others, was agreed to unanimously.

The CHAIRMAN next moved, "That the interim dividends, at the rate of 6 per cent. per annum, paid upon the preference shares, and at the rate of 5 per cent. per annum paid upon the ordinary shares of the company for the six months ended December 31st, 1892, be confirmed, and that dividends be declared upon the preference shares at the rate of 6 per cent. per annum, and upon the ordinary shares of the company at the rate of 7 per cent. per annum for the six months ended June 30th last, and that the same be paid on September 1st, 1893."

Col. F. G. STEWART seconded the resolution, which was agreed to.

The election of Mr. Arthur Ayres to a seat at the board was confirmed, and the retiring directors (Messrs. Braithwaite and Van Tromp) were elected. The auditors (Messrs. Cooper Brothers and Co.) were also reappointed.

Votes of thanks to the chairman, directors and staff, closed the proceedings.

Stock Exchange Announcements.—Application has been made to the Stock Exchange Committee to allow the following to be placed in the official stock and share list:—Brush Electrical Engineering Company, Limited—Further issue of 15,000 preference shares; 10,000 ordinary shares. Commercial Cable Company, Limited—Further issue of $2,284,000 capital stock. Electric Construction Company, Limited—Ordinary shares in lieu of those of the old company.

The Stock Exchange Committee have appointed August 30th a special settling day in Eastern and South African Telegraph Company, Limited (Mauritius Subsidy)—£200,000 (part of £300,000) 4 per cent. registered mortgage debenture, Nos. 1 to 8,000; and ordered the undermentioned securities to be quoted in the official list:—Eastern and South African Telegraph Company, Limited (Mauritius Subsidy)—£200,000 (part of £300,000) 4 per cent. registered mortgage debentures, Nos. 1 to 8,000. National Telephone Company, Limited—Further issue of 25,730 ordinary shares, Nos. 458,868 to 484,597; 28,284 5 per cent. non-cumulative third preference shares, Nos. 90,951 to 119,234; £198,540 (part of £273,523) 4½ per cent. debenture stock.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending August 27th, 1893, amounted to £716; week ending August 28th, 1892, £805; decrease £89; total receipts for half-year, 1893, £6,628; corresponding period, 1892, £6,190; increase £438.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending August 25th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2 810.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.‡	Closing Quotation, August 23rd.	Closing Quotation August 30th.	Business done during week ended August 30th, 1893. Highest.	Lowest.
184,500*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,134,640*l*	Anglo-American Telegraph, Limited	Stock	49 — 50	49½ — 50½	49	48½
2,932,680*l*	Do. do. 6 p. c. Preferred	Stock	92 — 93	92 — 93	92⅝	91½
2,932,680*l*	Do. do. Deferred	Stock	9 — 9½	9⅛ — 10	9⅛	...
130,000	Brazilian Submarine Telegraph, Limited	10	11¾ — 12⅛	11¾ — 12⅛	11⅞	11⅝
18,700*l*	Do. do. 5 p. c. Bonds	100	99 —103	99 —103	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	107 —111	107 —111	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	3 — 3¼	3 — 3¼	...	...
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2 — 2¼	2 — 2¼	2¼	...
125,000*l*	Do. do. 4½ per cent. Debenture Stock	Stock	107 —109	107 —109	...	...
20,510	Charing Cross & Strand Electricity Supply Nos. 1 to 6, 215 to 718, and 10,001 to 30,000	5	5 — 5⅛	5 — 5⅛	...	...
44,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	2 — 3	2 — 3	...	...
630,000*l*	City and South London Railway	Stock	35 — 37 xd	35 — 37	36⅜	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	11 — 11⅛	11 — 11⅛	...	...
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	12⅛ — 13	12⅛ — 13	13	12⅛
$7,716,000	Commercial Cable, Capital Stock	$100	120 —130	120 —130	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	1/16 — 1/16	1/16 — 1/16	⅛	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	4½ — 5 xd	4 — 5	...	...
50,000*l*	Do. do. 5 p. c. 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	100 —103	98 —102	...	...
16,000	Cuba Telegraph, Limited	10	11½ — 12⅛	11½ — 12⅛	12⅜	11⅞
6,000	Do. do. 10 p. c. Preference	10	18½ — 19½	18½ — 19½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2⅞ — 3⅛	2⅞ — 3⅛	...	...
6,000	Do. do. 10 p. c. Preference	5	8½ — 9½	8½ — 9½	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅛ — 11⅞ xd	11⅜ — 11⅝	11⅝	11½
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜ — 15	14⅜ — 15⅛	15⅛	14⅞
70,000	Do. 6 p. c. Preference	10	16¼ — 16⅜	16 — 16½	16⅛	16¼
105,900*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	106 —109	106 —109	...	...
1,294,100*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	112 —115	111 —114	114	111
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	15 — 15¼	15 — 15½	15½	15 1/16
62,700*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	102 —105	102 —105	...	...
222,800*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	110 —113	110 —113	111½	110
108,700*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	100 —103	100 —103	102½	...
146,800*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	100 —103	100 —103	...	...
300,000*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	100 —103	100 —103	...	...
200,000*l*	Do. 4 p. c. Reg. Mt. Debs. (Mauritius Subsidy) 1 to 8,000	25	... ...	102 —105	103⅜	...
49,900	Electric Construction, Limited, Nos. 101 to 45,100	10	1½ — 1⅝	1½ — 1⅝	1⅝	1½
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ...	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	⅛ — ¼	⅛ — ¼	...	...
91,195	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	¼ — ⅜	¼ — ⅜	7/16	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	⅜ — ⅝	⅜ — ⅝	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	1 — 2	1 — 2	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅝ — 9⅞	9⅝ — 9⅞	9⅞	9⅝
180,042	Do. do. 6 p. c. Preference	10	15 — 15¼	15 — 15½	15½	15
150,000	Great Northern Tel. Company of Copenhagen	10	19½ — 20	19¾ — 20¼	19⅞	19⅝
200,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105 —108	105 —108	...	...
12,134*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½ — 5½	4½ — 5½	...	...
9,600*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	6 — 7	6 — 7	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21½ — 22½	21½ — 22½	22¼	22
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	39 — 42	39 — 42	...	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	1½ — 2½	1½ — 2½	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	4 5/16 — 4 7/16	4 3/16 — 4 5/16	4 7/16	4 1/16
10,000	Do. do. fully paid	5	6¼ — 6½	6⅜ — 6⅝	6½	5⅝
37,548	London Platino-Brazilian Telegraph, Limited	10	4 — 6	4 — 6	...	...
100,000*l*	Do. do. do. 5 p. c. Debentures	100	107 —110	107 —110	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	5⅜ — 6¼	5⅜ — 6¼	6⅛	5⅞
50,000*l*	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	102 —105	102 —105	...	...
15,000	Monte Video Telephone Co., Ord., Nos. 1 to 15,000 fully paid ...	5	1½ — 2½	1½ — 2½	...	...
28,000	Do. do. 6 p. c. Pref., Nos. 1 to 28,000 fully paid	5	3 — 4	3 — 4	...	...
458,867	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜ — 4⅝	4⅜ — 4⅝	4 1/16	4⅜
15,000	Do. 6 p. c. Cum., 1st Preference	10	14½ — 15½	14½ — 15½	...	...
15,000	Do. 6. p. c. Cum. 2nd Preference	10	14 — 15	14 — 15	14⅜	14¼
90,950	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	5¼ — 5½	5¼ — 5½	5 1/16	5¼
726,477*l*	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	111 —113	111 —113	112⅜	111½
48,800	New Telephone, Limited, Nos. 25,901 to 74,700 ... (£2 paid)	10	... ...	... ...	...	...
6,452	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	5 — 6	5 — 6	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	3/16 — 5/16	5/16 — 7/16	...	...
100,000*l*	Pacific and European Tel., Ltd., 4 p. c. Guar. Debs., Nos. 1 to 1,000	100	100 —103	100 —103	...	...
11,802	Reuter's Limited	8	4½ — 5½	4½ — 5½	...	...
19,980	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	6½ — 6⅝	6½ — 6⅝	6½	...
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	7⅜ — 8½	7⅜ — 8½	8¼	...
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	...	...
78,942	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	2 — 2½	1⅝ — 2¼	2 3/16	...
37,350	Telegraph Construction and Maintenance, Limited	12	33 — 35	32 — 34	34⅛	34
150,000*l*	Do do. do. 5 p. c. Bonds, red. 1894	100	101 —104	101 —104	...	...
58,000	United River Plate Telephone, Limited	5	2 — 2½	2 — 2½	...	...
146,370*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	90 — 100	90 —100	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	5½ — 6½	5½ — 6½	...	...
260,900*l*	Do. do. do. 5 p. c. Debentures	100	99 —102	99 —102	...	...
30,000	West Coast of America Telegraph, Limited	10	2 — 3	2 — 3	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	97 —101	97 —101	...	...
64,242	Western and Brazilian Telegraph, Limited	15	6½ — 6⅝	6½ — 6⅝	6⅝	...
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5⅝ — 6½	5⅝ — 6½	5⅞	5 13/16
33,129	Do. do. do. 5 p. c. Deferred	7½	1½ — 1⅝	1½ — 1⅝	...	...
178,200*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
222,700*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	1 — 1½	1 — 1½	1 3/16	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10¼ — 10⅜	10¼ — 10⅜	...	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	9 —10	9 — 10	...	...
80,000*l*	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	105 —108	105 —108	...	...
$1,214,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
169,000*l*	Do. do. 6 p. c. Sterling Bonds	100	101 —104	101 —104	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	5 — 5⅛	5 — 5⅛	5⅜	...

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅜—6.—Electric and General Investment, shares of £5 (£1 paid), 1½—2½.—Founders' shares, 200—225.—House to House Company (£5 paid) 1½—2½.—Do. 7 per cent. Preference of £5, 5—5¼.—Do. 6 per cent. Debentures of £100, 97—102.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5¼—5⅝, 1st Preference Cumulative 6 per cent., £5 (fully paid) 6—6¼.—Manchester, Edison and Swan Company, 49 (£1 paid), ¼—⅜.—Queen Anne's Mansions Lighting and Heating 6 per cent. £10 Debentures, 101—103.

Bank rate of discount, 5 per cent. (August 24th, 1893).

ON THE TRANSMISSION OF ELECTRIC SIGNALS THROUGH SPACE.*

BY W. H. PREECE, F.R.S.

(*Concluded from page* 212.)

3.—ELECTRO-MAGNETIC INDUCTION.

Magnetic force is that which produces or tends to produce polarisation in magnetisable matter, viz., iron, nickel and cobalt, and electro-magnetic disturbance in non-magnetisable matter and the ether. It excites lines of magnetic force and becomes a stress. An electric current in a conductor is a seat of magnetic force. It establishes in its neighbourhood a magnetic field.

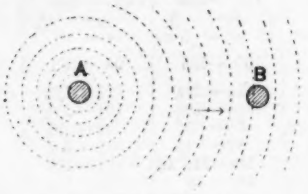


FIG. 8.

The lines of force (fig. 8) in this field are equivalent to circles in a plane perpendicular to the direction of the current, which, during the rise of the current in A, flow outwards, and during the fall of the current flow inwards, like the waves on the surface of smooth water when a stone is dropped into it, but moving with the speed of light. Thus any other linear conductor, B, placed in this field parallel to A, is cut at right angles to itself by these lines of force—in one direction as the current rises, and in the other direction as the current falls. The projection of lines of magnetic force through a linear conductor in a direction perpendicular to its length excites electric force in that conductor; and, if the conductor be continuous and form part of a circuit, it establishes voltage, and, therefore, a current in this secondary circuit. Now, the strength of this secondary current (c_2), depends on the strength of the primary current (c_1), on the rate at which it rises or falls $\left(\frac{d\,c}{d\,t}\right)$, on the resistance of the secondary circuit (r_2), on the distance which separates the two circuits (d), and on the length of the inductive system (l). The direction of the secondary current everywhere is reverse to that of the primary during its rise and in the same direction during its fall.

If the two circuits are separate and independent, this action between them is called mutual induction; but if B be a part of the same circuit, A, it is called self-induction. The amount of induction is dependent also on the magnetic elements present in the conductors and in the space between them. This is measurable in its own unit (which it is proposed to call "Henry"), is called *inductance*, and is usually indicated by L or M, according as the question dealt with is self or mutual induction.

EXPERIMENTAL INVESTIGATION.

Since 1885 I have had a vast number of experiments made to thresh out the laws and conditions that determine the distance at which these magnetic disturbances can be usefully evident. The instrument used to receive these signals has been generally the telephone, but many absolute measurements have been made with a very sensitive reflecting galvanometer. The judgment required to determine the relative intensity of sound in a telephone is a very variable and uncertain agent, even though many observers be utilised and the same experimenters perform with the same apparatus. But this does not apply to the observation of the limiting audible intensity of signals. The point where sound ceases is obtained with concordant and satisfactory results when the mean judgment of several observers using the same telephone is made use of. I never use less than three observers, and sometimes have employed as many as seven. By this means, we observe by what I call the *average normal ear*.

I.—To prove that the effects were due to Electro-magnetic Induction.

Conductors of copper wire insulated with gutta-percha were formed into quarter mile squares (fig. 9) and laid on a level plain at a distance of a quarter of a mile apart.

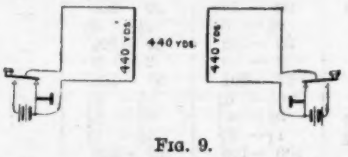


FIG. 9.

Arrangements were made for sending vibratory or alternating currents which could be broken into Morse signals by means of a telegraph key. Telephones were used as receivers, which transformed these signals into buzzing dots and dashes.

On closing the circuit in one square and sending signals, conversation could be readily held between the two operators by means of the Morse code. Now, obviously, earth conduction could play no part in this transmission of signals, for the squares were insulated throughout from the earth.

Next, in order to ascertain to what extent, if any, electrostatic effects were observable, one pole of the battery used was put to earth, and the further end of each square was disconnected (fig. 10).

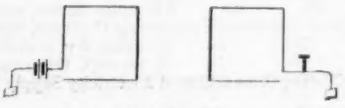


FIG. 10.

Now, by this arrangement, the mean electric force of one square was doubled, as compared with the former experiment, where the circuit was completed, but no effect was observed in the second square, either in the receiving telephone or with the reflecting galvanometer. The squares were even superposed at a distance of only 15 feet apart, the upper one being suspended on poles, and the lower one lying on the ground, but without any result. Hence, the effects observed in this experiment were clearly due to electro-magnetic induction.

II.—To prove that the effects increased directly with the strength of the primary current used and diminished with the resistance of the secondary current.

a. Two quarter mile squares of insulated wire were opposed to one another, and the distances between the front faces varied from 8 yards to 192. Currents of 1 and 2 ampères respectively were sent into one square, and the induced effect in the second square with 2 ampères was invariably twice that with 1 ampère. The measurements were made with a reflecting galvanometer.

b. Open wires were placed parallel to one another, and a mile apart horizontally (fig. 11). The primary circuit was two miles long. The other, the secondary circuit, was divided into two equal one-mile lengths. With a primary current of ·22 ampère the vibrations were just audible in a

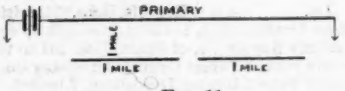


FIG. 11.

telephone fixed to either of the single mile lengths of the secondary, the total resistance in the latter circuit being 85 ohms. With a similar current (·22 ampère) in the primary and the secondaries joined into a two-mile length, the same limit of audibility was reached when the resistance in the secondary was doubled, that is, it was raised to 170 ohms. Next, the current in the primary was doubled or increased to ·44 ampère; and with a one-mile secondary the total resistance had to be doubled in order to reach the same limit. Finally, when the current in the primary was raised to ·88 ampère—four times the original figure—then the same limit was reached when the resistance was quadrupled.

III.—To find how the effects varied with the length of the inductive system and with the distance separating them.

The law for variation of length and distance is very complicated and depends wholly on the form of the circuit and its various reactions. It may be briefly summarised as follows, but the experiments upon which these conclusions are drawn are given as an appendix, together with the equations developed from them.

Let l = length and d = distance apart of two conductors assumed equal and similar, then

a. With two infinitely long straight wires, it varies inversely as d alone.

b. With one infinitely long straight wire and a wire of finite length, it varies as

$$\frac{l}{d}.$$

c. With one infinitely long straight wire opposed to a rectangle, the law becomes

$$2\,l\left(\frac{1}{d}-\frac{1}{D}\right)$$

where D is the distance from the face to the back of the rectangle.

d. Where the rectangle is replaced by a square, the above formula becomes

$$\frac{2\,l^2}{d\,(l+d)}$$

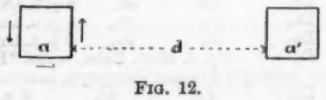


FIG. 12.

e. With a rectilinear wire of finite length opposed to a square, the length of the former being equal to the face of the latter, it varies as

$$\frac{l}{d}$$

* Read at the Chicago Exhibition on Wednesday, August 23rd.

f. With two squares of equal dimensions opposed to one another (fig. 12), the effect varies, where l is great compared with d, as

$$\frac{l}{\sqrt{a}}$$

but when d exceeds half l, it varies as

$$\frac{l}{d}$$

NOTE.—With cases *c*, *d*, *e* and *f*, if d became very great, the effect would diminish and ultimately disappear, owing to the opposing current in the back of the square having practically the same influence as that in the front. When d is very great, the effects due to a and a' may be neglected.

g. With two rectilinear wires of equal length if the effect of the magnetic waves due to the return current through the earth be neglected, then when l is great compared with d, it varies as

$$\frac{l}{d}$$

but when d is great compared with l, it varies as

$$\frac{l^2}{d^2}$$

The complete formula for the aerial portion of the circuit is as follows:—

Let c_1 = current through primary,
q_2 = quantity induced in secondary,
r_2 = resistance of secondary,
l = length of either wire,
d = distance between wires,
then M constant in C.G.S. units,

$$q_2 = \frac{c_1}{r_2} \frac{\sqrt{l^2 + d^2} - d}{d} \times \text{M}.$$

The complete formula must of course allow for the reverse effect of the return circuit through the earth. I hope later to obtain sufficient data on which to base such a formula.

The value of M, obtained from a series of experiments on two parallel squares of wire, 1,200 yards in length, and 5 yards apart, was found to be ·003.

h. The difference in water as compared with air is not very marked. In certain experiments, which were considered reliable, and which appear on Table I., it was about 6 per cent. more in the air than in water. The result was probably due to the magnetic waves being degraded into electrical currents in traversing the conducting sea water.

4.—PRACTICAL EXPERIMENTS.

The Bristol Channel proved a very convenient locality to test the practicability of communicating across a distance of 3 and 5 miles without any intermediate conductors. Two islands, the Flat Holm and the Steep Holm, lie off Penarth and Lavernock Point, near

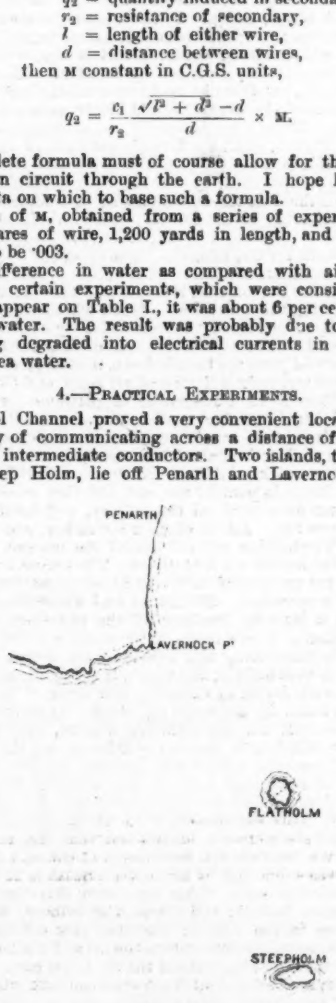


FIG. 13.

Cardiff, the former having a lighthouse upon it. On the shore two thick copper wires combined in one circuit were suspended on poles for a distance of 1,267 yards, the circuit being completed by the earth. On the sands at low water mark, 600 yards from this primary circuit and parallel to it, two gutta-percha covered copper wires and one bare copper wire were laid down, their ends being buried in the ground by means of bars driven in the sand.

One of the gutta-percha wires was lashed to an iron wire to represent a cable. These wires were periodically covered by the tide which rises here at spring to 33 feet. On the Flat Holm, 3·1 miles away, another gutta-percha covered copper wire was laid for a length of 600 yards.

There was also a small steam launch having on board several lengths of gutta-percha covered wire. One end of such a wire, half a mile long, was attached to a small buoy, which acted as a kind of float to the end, keeping the wire suspended near the surface of the water as it was paid out while the launch slowly steamed ahead against the tide. Such a wire was paid out and picked up in several positions between the primary circuit and the islands.

The apparatus used on shore was a 2 H.P. portable Marshall's engine, working a Pike and Harris's alternator, sending 192 complete alternations per second of any desirable strength up to a maximum of 15 ampères. These alternating currents were broken up into Morse signals by a suitable key. The signals received on the secondary circuits were read on a pair of telephones—the same instruments being used for all the experiments.

The object of the experiments was not only to test the practicability of signalling between the shore and the lighthouse, but to differentiate the effects due to earth conduction from those due to electro-magnetic induction, and to determine the effects in water.

I have already alluded to the way in which the lines of current flow were mapped out. It was possible to trace without any difficulty the region where they ceased to be perceptible as earth currents and where they commenced to be solely due to electro-magnetic waves. This was found by allowing the paid-out cables, suspended near the surface of the water, to sink. Near the shore, no difference was perceptible, whether the cable was near the surface or lying on the bottom, but a point was reached, just over a mile away, where all sounds ceased as the cable sank, but were recovered again when the cable came to the surface.

The total absence of sound in the submerged cable rather surprised me, and it leads to the conclusion, either that the electro-magnetic waves of energy are dissipated in the sea water, which is a conductor, or else that they are reflected away from the surface of the water like rays of light.

Experiments on the Conway Estuary showing the relative transparency of air and water to these electro-magnetic waves, tend to support the latter deduction, for if much waste of energy took place in the water, the difference would be more marked. As it is, we have ample evidence that the electro-magnetic waves are transmitted to considerable distances through water, though how far remains to be found.

There was no difficulty in communicating between the shore and Flat Holm. Messages were read. Mr. Gavey, who was making the experiment on the island, wrote me, "There was then somewhat a lengthened pause, due to a slight derangement of the machinery on the mainland, but at 2 p.m. I heard clearly and distinctly the following, 'Here Haskayne' (one of his assistants) 'with a message from Mr. Preece for Mr. Gavey.'" I was in London that day. "Then followed the announcement of the sad and sudden death of Mr. Graves, which cast a gloom over the success of the experiment. It seemed an extraordinary fact, that the first readable message transmitted for such a distance by such means should announce the death of the head of the Technical Department."

The distance between the two places was 3·1 miles. The attempt to speak between Lavernock and Steep Holm was not so successful. The distance was 5·35 miles, but though signals were perceptible, conversation was impossible. There was distinct evidence of sound, but it was impossible to differentiate the sounds into Morse signals. We were just on the limit of audibility, and we were using our maximum power. If either line had been longer, or the primary currents stronger, we should have spoken as was done at Flat Holm.

The fact indicated by the formula for parallel wires that the limiting distance increases directly with the square of the length of the circuits, has a very important bearing on the practical results of these experiments, for it shows that if we can make the length of the two lines long enough, it would be easy to communicate across a river or a channel. Of course, as previously pointed out, the formula does not take into account the effects of the reverse magnetic waves generated by the return current through the earth, and at present no data exist on which a satisfactory calculation can be based; but, for example, there is little doubt that two wires, 10 miles long, would signal through a distance of 10 miles with ease.

Although communication across space has thus been proved to be practical in certain conditions, those conditions do not exist in the cases of isolated lighthouses and lightships, cases which it was specially desired to provide for. The length of the secondary must be considerable, and for good effects, at least equal to the distance separating the two conductors. Moreover, the apparatus to be used on each circuit is cumbrous and costly, and it may be more economical to lay an ordinary submarine cable.

Still, communication is possible even between England and France, across the Channel, and it may happen that between islands where the channels are rough and rugged, the bottom rocky, and the tides fierce, the system may be financially possible. It is, however, in time of war that it may become useful. It is possible to communicate with a beleagured city either from the sea or on the land, or between armies separated by rivers, or even by enemies.

A use to which these electro-magnetic disturbances can be applied is to indicate to ships their contiguity to lighthouses and land falls. Experiments are being made in this direction by Mr. Stevenson of the Northern Lights Commission on the coast of Scotland, but no results have yet been published. He proposes to submerge a cable on a given fathom line through which special automatic distinguishing signals are being sent, so that a ship approaching or crossing this line can pick up these signals on board and learn her true position.

I have also pointed out that as these waves are transmitted by the ether they are independent of day or night, of fog or snow or rain, and, therefore, if by any means a lighthouse can flash its indicating signals by electro-magnetic disturbances through space, ships could find out their positions in spite of darkness and of weather. Fog would lose one of its terrors, and electricity becomes a great life-saving agency.

APPENDIX.

I.—EXPERIMENTS TO DETERMINE THE ELECTRO-MAGNETIC INDUCTION, BOTH IN WATER AND AIR, BETWEEN A RECTANGLE AND A FINITE LINE OF LENGTH EQUAL TO THE FACE OF THE RECTANGLE.

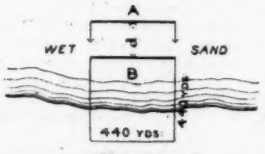


FIG. 14.

Currents were sent through the rectilinear circuit, A, by means of a suitable key, and the induced effect on the rectangle was observed on a carefully adjusted reflecting galvanometer.

EXPERIMENT WITH CONDUCTORS COVERED WITH SEA WATER.

d. yds.	Relative values of *d.*	Current through A (amps.).	Discharge deflection from B.	Equivalent in micro-coulombs.	Remarks.
100	1	2·00	16	·024	18 feet water over A.
200	2	,,	8	·012	
300	3	,,	5½	·008	Constant — 1·5 v.
400	4	,,	4	·006	⅓ mf. = 330.
800	8	,,	2	·003	

EXPERIMENT WITH CONDUCTORS IN AIR.

d. yds.	Relative values of *d.*	Current through A (amps.).	Discharge deflection from B.	Equivalent in micro-coulombs.	Remarks.
100	1	2·00	17	·026	Low water.
200	2	,,	8½	·013	
300	3	,,	5½	·008	
400	4	,,	4	·006	
800	8	,,	1½	·0023	

II.—EXPERIMENTS TO DETERMINE THE ELECTRO-MAGNETIC INDUCTION BETWEEN TWO RECTANGLES OF EQUAL DIMENSIONS.

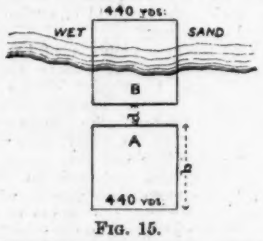


FIG. 15.

l.	*d.*	Relative values of *a.*	Current through A. (amps.)	Discharge deflection from B.	Equivalent in micro-coulombs.	Variation of deflection by formula $\frac{40}{\sqrt{d}}$	Remarks.
yds.	yds.						
440	8	1	2	40	·059	40·0	When current was
,,	16	2	,,	28½	·042	28·3	reduced to 1
,,	24	3	,,	23	·034	23·1	ampère the in-
,,	32	4	,,	19½	·029	20·0	duced discharge
,,	64	8	,,	11½	·017	14·1	was halved.
,,	96	12	,,	8	·012	11·5	Constant — 1·46 v.
,,	192	24	,,	4½	·007	8	⅓ mf. = 330.

III.—EXPERIMENT WITH A RECTILINEAR WIRE FOUR TIMES THE LENGTH OF THE FACE OF THE RECTANGLE.

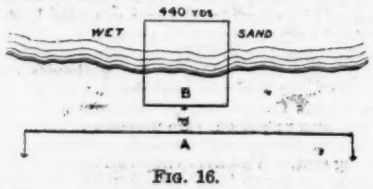


FIG. 16.

d.	Current through A (amps.)	Discharge deflection from B.	Equivalent in micro-coulombs.
192	2	20	·030

THE OCONTO INCANDESCENT LAMP CASE.

II.

As in last week's report of this case, we will confine our remarks mainly to such points as were not introduced, or not fully so, in the previous Goebel trials. The principal incident brought forward in the defendants' case was the testimony of William A. Goebel, one of the claimant's younger sons, who resides in San José, California, and is an actor by profession. This witness, unlike most of the others, was cross-examined by the complainants' counsel, and in both examination and cross-examination he displayed a very vivid recollection of the events which occurred long ago. His acquaintance with incandescent lamps dates from early childhood. He, his brother Otto, his sister Anne, and sometimes his brother Henry, assisted his father to make these lamps. He remembered perfectly the various machines used for splitting bamboo for filaments, one of which was made out of an old French clock movement plate.

In cross-examination little or nothing transpired to strengthen the complainants' case. He remembered that Dixon's stove polish had been used to cement the carbons to the wires long before his brother Otto went to work at the American Electric Company. His father gave Otto some of the cement when he began to work with that company. His father also gave Otto a lamp to take to the works, saying, "Now we can tell how it burns on a dynamo." It was after this that his father was engaged by the company. The lamp was a tube lamp, as were all the lamps. After his father ceased to work for the American Company the latter experimented on a semi-incandescent lamp, enclosed in a vacuum. Witness sketched the shape of the bulbs, which were some 12 inches long by 6 inches in diameter. His father could not manage the glass-blowing well. Reverting to the old incandescent lamps, he stated that they were always hung on wires in order to run them; but once his father turned a socket in hard rubber, to which a lamp was fixed, and it was so arranged that on turning the lamp it was switched on or off at will. Heger had made tubular lamps, but those he made were mostly bulb lamps. The re-entrant lamps made by his father and Heger were not constructed in the same way. Heger's lamps were made by sealing together two separate pieces of glass, while his father's was made of one piece only, and sucked in while hot.

The mercury pumps used by Goebel were then elaborately described, and next the furnace and crucibles that were used to bake the carbons. Referring to the furnace, he said his father made one out of a cylinder of iron like a boiler, and it was riveted. When he commenced to work for the Electric Light Company they put a new furnace in his house, but it did not work well, and he replaced it with the old one. (In the Boston trial it was stated that the kitchen range was used for heating the crucibles.) Asked whether he remembered whether his father ever heated platinum wire by electricity so as to give light, he said, "I remember he had a cigar-lighting machine that, when he would press the handle down, a little piece of platinum would get red hot and light a little coal oil lamp, and then you could light a cigar. That is all I remember of platinum being lighted." He remembered his father had made some very small lamps about the size of a hen's egg, or smaller, with carbons about ¼ inch long. They burnt very well, and required less battery power. He had seen as many as seven or eight of them. He also described how his father used to run the lamps in parallel arc, and how they would dull down when two or three were used on the battery, and brightened again when only one was run. Asked whether his father, when exhausting lamps by the Torricellian method passed the current through the carbon, he replied he did do it at times. The carbons would break occasionally in the process of exhaustion, and great care had to be taken during the operation. His father had shown him how to test the vacuum in a lamp by breaking off the pip when placed under mercury, and observing how much of the metal was drawn in.

In addition to introducing this evidence, the defendants charged the complainants with bribing, and attempting to bribe certain of their witnesses, and with fraud, by declaring that some of their witnesses asserted things that they never did say at all. As an instance of the latter misdemeanour, the complainants' witness, Paul H. Bate, deposed that he called with another gentleman on the defendants' witness, Mary Meisinger, a short time ago, and had been told by this lady that she had never seen, prior to her marriage in 1881, any incandescent lamp which had been made by Goebel, or by her husband, Adolph Goebel. This she denied, both in examination and cross-examination, and she moreover maintained that she told them the very contrary, viz., that *she had* seen lamps in Goebel's store. In this statement she was supported by her mother, Susanna M'Donald, who was present at the interview. Other cases were also cited to the same effect. As regards bribery, and attempt at bribery, there was the clearest evidence in the case of the poor sick old man, Nicholas Finck. This witness had long known Goebel and his lamps, and had given evidence for the defendants in the St. Louis case. Now, Finck was an inventor, and had patented a certain can lock, which patent he had tried to sell through the instrumentality of a comparative stranger, named R. D. Gibby. Subsequent to the date of Finck's affidavit for the defendants, Gibby called one day to say that he could sell this patent before 2 p.m. to some one connected with the Edison people for $1,500, if he (Finck) could have been mistaken in former affidavit. Gibby, who was subsequently subpœnaed by the defendants, stated that Finck at one time seemed to accede, and said something to the effect that he did not know how to arrange his statements. But Gibby replied that he could fix that. It would not be surprising if the poor old man did waver under so great a temptation as stated by the hostile witness Gibby; but the result was that he resisted and remained staunch. Another instance was that of Baldwin Sebastiani, one of the defendants' witnesses, who, since the date of his affidavit, was called to the office of one of the complainants' lawyers, called Campbell, and given to understand that if he could swear differently

he could have money, which was placed before his eyes on the table. He says the money wasn't offered to him, though he guesses he could have had it if he would have sworn differently.

"With Henry Goebel, Jun.," said Mr. Kenyon, in summing up, "the methods of bribery were successful. He is evidently the weak member of Mr. Goebel's family, and was the right person to be dishonestly approached. Prior to about two months ago, more or less, he had for some time been aiding defendants to hunt up the people who were likely to know about his father's early lamps. During this work he from time to time brought reports to defendants' counsel that he had received offers of large sums of money—once many thousands of dollars—to leave the defendants and serve the complainants. His stories of attempted bribery by complainants became larger and larger. He became more and more restless and unmanageable, and defendants were at last forced to give him to understand that they distrusted him. Very shortly after this he stated to defendants' counsel that he had secured employment at Nagelsmith and Rothschild, 510, Broadway, and should not help defendants any longer. This statement was false. He did not enter that employment, nor any other, except it be complainants'. He had, previous to this defection, been in the habit of helping the case for his father, and of coming to the office of defendants' counsel, 38, Park Row, almost daily. He came there no more. From that date he had had large sums of money at times, and has given evidences of having plenty of money; has been intoxicated a great part of the time, unfit to be conferred with or examined as a witness, even if defendants were disposed to subpœna him, which they are not. He has been a constant, wilful annoyance to his father, has tried to persuade him and his other relatives to do 'different from what is right,' has been brutal to his family. He has been pressed for interviews with defendants' counsel, and has been too intoxicated to know what he was about, and on one occasion, when persuaded to come to the house of Mr. W. H. Kenyon, ran away at the end of ten minutes, before he could be conferred with. He has been in association with complainants' witness, Hoffman, very constantly both before and since his defection, and Hoffman has distinctly offered to bribe him to go on the other side. On February 16th, 1893, Henry Goebel, Jun., signed the following statement made by him on that date:—

"'I, Henry Goebel, Jun., of the City of New York, hereby certify that this 16th day of February, 1893, I was approached by Max Hoffman, proprietor of the East Side Hoffman House, corner of Seventh Street and Avenue A, New York City, and asked what I would take to go on to the other side. I said I thought I was worth twenty-five or fifty thousand dollars. He then said to me that he thought he ought to make ten thousand out of it, and that it ought to be worth ten or twenty-five thousand to me to go on the other side, or to get out of the country. He then said he would speak to the other party to-morrow. He asked me if I would take a certified cheque? I said No, I would only take money. He furthermore said I would get a position for life in the company on the other side. When Hoffman first spoke to me I answered him, and carried on the conversation to bring him out. This conversation took place between three and four o'clock in the afternoon, in the saloon in the East Side Hoffman House. Later on, between five and six in the afternoon, I went to the office of Witter & Kenyon, 38, Park Row, and immediately told Alan D. Kenyon about the interview with Mr. Hoffman referred to above.

"'Dated New York, Feb. 16th, 1893.

"'HENRY GOEBEL, JUN.

"'Witness: ALAN D. KENYON.'"

The rest of Mr. Kenyon's summing up was largely devoted to the argument used in the St. Louis case, viz., that the carbon filament having been proved to be old, Edison's patent must necessarily be null and void, except in so far as a particular method of making and coiling the filament was concerned.

DECISION.

On Thursday, July 20th, Judge Seamans, of the U.S. Circuit Court, sitting at Milwaukee, granted the injunction demanded by the Edison Electric Light Company against the Electric Manufacturing Company, of Oconto, Wis. The judge, in delivering opinion, reviewed at some length the past history of the lamp litigation, and then the more recent trials that have been heard. He had considered very carefully the question as to how far fresh evidence should affect a patent that had already been upheld—whether on the one hand it should be sufficient simply to raise doubt in the mind, or, on the other, the matter should be absolutely convincing and proved. He had examined the authorities cited by Judge Hallet, and others noted by the defendants, but they did not impress him as supporting the rule held in that opinion, and he agreed rather with Judge Colt that "there is not that measure of proof demanded" by the rule. After dealing with Edison's invention, and Goebel's history, he said:

"I will refer to some of the doubts raised, upon the defendants' showing, as to the actual components of these alleged Goebel lamps, remarking that the testimony of the numerous witnesses, however honest, speaking of such delicate structures seen by them many years ago, cannot justly be accepted as absolute verity.

"1. The fundamental thread-like carbon burner of Edison only became necessary as a means to subdivision of electric light, which was not contemplated by Goebel. The latter operated with a primary battery, for which the larger 'pencil' form of carbon or other material would answer as well, would be more stable and more easily made. This filament is most delicate and difficult to make, and must have a high vacuum or it will be instantly consumed. It seems unnecessary and undesirable for his purpose, and no satisfactory reason is given for its adoption by him.

"2. The Goebel lamps are not shown to have had the high vacuum required for anticipation. His principal statement must be taken that he exhausted his lamps by the Torricellian method in the years prior to 1879, and I think it is abundantly shown, although not without some contradiction, that such a method could not produce the vacuum necessary to prevent disintegration of the carbon; and it seems doubtful whether it could be employed at all with this delicate carbon in the receiver. If that vacuum was wanting, the claim fails.

"3. No motive is shown for such constant manufacture of these lamps throughout the years from 1854 to 1880, involving so much of time and expense, and especially of great expense in maintaining the batteries for their use, and no attempt to dispose of even one, or to utilise them for domestic purposes excepting in a few stray instances. It seems improbable that the constant practice here asserted, and so useful for the purposes of this defence, would have been kept up without clear object.

"4. Why did he not apply for a patent? He was not ignorant of the patent laws, for in 1865 he is shown to have applied for a patent on a sewing machine hemmer, and in 1881 he is found applying for some minor improvements, one of them being a coil shown in his exhibit lamps.

"5. The lamps which Goebel produced at Boston, as original lamps, made in the early years, were four, called exhibits 1, 2, 3 and 4. The first three only were produced at the hearing, with his original affidavit, the fourth being in the hands of counsel for defendant, but withheld because of doubts as to its authenticity—which doubts were afterwards cleared to their satisfaction, and this lamp then introduced by leave of Court, with additional and explanatory proofs. The first three had copper and iron leading-in wires, were of what Goebel calls 'meat saw' pattern, and show no vacuum now, and if fully proved would not constitute anticipation of Edison. No. 4, called the 'hairpin' pattern, has the requisites, including a vacuum, although probably not the high vacuum. It is not now operative by reason of some defect. Goebel swears that it was operated but experts who have examined the defect swear that it has existed from its manufacture, and it could not have operated. This lamp shows the highest excellence of the glass-blower's art, is stated by experts to be beyond the ability of any amateur; and many peculiarities are pointed out in the perfect shape of the carbon, the glass bridge and position of leading-in wires, which seem to show adoption of methods which have been produced and developed from the experience of commercial manufacture with Edison's invention. The statement as to its make, its keeping, or its having been operated, are not clear or convincing to the Court, if they have been made so to counsel. Exhibit lamps Nos. 9 and 11, brought to St. Louis, are no more satisfactory than No. 4.

"6. After Goebel's employment in lamp making by the American Company his claim of anticipation received some attention, and he had negotiation with one Dreyer, in 1882, for arranging a company to exploit the claims. It failed because he was then, apparently, unable to produce an original lamp. Later it was investigated by eminent patent lawyers, at various times, and apparently with great care and interest to employ it in defences against this patent, and also by one in behalf of complainant, and all rejected it as not well founded. Prof. Thomson, of the Thomson-Houston Company, inves tigated it in 1882 when it would have been of vital interest to his company to make use of it against this patent, if tenable, and after visiting Goebel he rejected its consideration. Dr. O. A. Moses, an inventor with similar object, visited Goebel frequently, but came to the same conclusion and says he was unable to produce any lamp. These are potent circumstances to raise doubt.

"Coming to the new testimony produced for this hearing and which I have carefully considered, I find that the depositions of defendants are mostly cumulative, or in rebuttal of certain new affidavits produced by the complainant, and not here considered, but I cannot find that they remove any of the doubts above noted. On the other hand, affidavits now produced by complainants tend to show an admission by defendants' witness, Henry Goebel, Jun. (a son of the claimant), that he manufactured exhibit lamps Nos. 1, 2 and 3, in 1892, for the purposes of this case. There is no denial of this but it is claimed that this son is venal, and has deserted the defence to favour the complainant. One Heger, a glass-blower, swears that he made for Goebel while working with him, 'in the early eighties' lamps similar to No. 4, and he thinks he made this one at that time. As to a planer which was produced by Goebel as made by him at an early day, to cut bamboo for his carbon burners, one Korwan and Heger swear that it was actually made by the former in 1883. This is contradicted as to date by an affidavit produced by defendants.

"Upon the whole showing, I am satisfied that the complainants are legally entitled to preliminary injunction, and that it is the duty of the Court to grant it without evasion. As stated by Judge Colt, and often held, a bond by defendant is not the equivalent of the injunction which the law gives for the protection of the inventor in the exclusive privileges promised by his patent.

"Injunction will therefore issue, but with leave to defendants to move for requirement of a bond by complainants to indemnify the defendants for any damages they may suffer if it shall be finally held that the patent is invalid."

We are informed that the defendants will immediately require a bond from the complainants, and will appeal.

NEW PATENTS—1893.

15,409. "Improvements in electric switches." B. G. SMITH. Dated August 14th.

15,476. "Improvements in primary voltaic batteries." L. FALERO. Dated August 15th.

15,479. "Improvements in electric arc lamps." L. E. HOWARD. Dated August 15th. (*Complete.*)

15,486. "An automatic switch for electric and other light, applicable to a door." E. MANN and J. HOPWOOD. Dated August 15th.

15,510. "Improvements in electric arc lamps." J. BROCKIE. Dated August 15th.

15,519. "Improvements in electric engines." R. W. BARKER. (Communicated by the Lawrence Electric Company, United States.) Dated August 15th. (*Complete.*)

15,523. "Improvements in recording meters for electric light and power circuits." W. MCNEILL, J. H. TINDER, and S. P. KERR. Dated August 15th.

15,577. "Improvements in electric furnaces." F. CHAPLET. Dated August 16th.

15,610. "Improvements in apparatus for the electrolytical decomposition of brine and other liquids." F. G. BAILY and M. GUTHRIE. Dated August 17th.

15,617. "Improvements in apparatus for the electrolytical decomposition of brine and other liquids." F. G. BAILY and M. GUTHRIE. Dated August 17th.

15,663. "Improvements in the covers and frames of manholes, used for drainage work, electric light and other purposes." F. C. LYNDE. Dated August 18th.

15,669. "Apparatus for the electrolytic treatment of liquids." N. BROWNE. (Communicated by A. Vogelsang, Germany.) Dated August 18th. (*Complete.*)

15,681. "Improvements in electric accumulators or storage batteries." G. H. ROE and G. SUTNO. Dated August 18th. (*Complete.*)

15,690. "Improvements in electric marine governors." D. TWEDDLE. Dated August 18th.

15,715. "Improvements in or connected with means for the supply or distribution of electricity." W. G. LITTLE and C. W. G. LITTLE. Dated August 18th.

15,736. "Improvements in and relating to machinery for covering telegraph, telephone and electric cables and wires with lead or metallic compounds, also applicable for the manufacture of metallic pipes and the like." G. EDWARD and T. EDWARD. Dated August 19th.

15,776. "An improved electric apparatus termed 'gubernograph' for use on ships to indicate and register the position of the rudder and the reversing gear of the engine." J. L. HUBER. Dated August 19th.

ABSTRACTS
OF PUBLISHED SPECIFICATIONS, 1892.

1,096. "Improvements in electric signalling on trains." A. SHIELS. Dated January 19th. Consists in fitting one or more semaphore or signal arms, worked by electricity on each of the carriages. 2 claims.

1,571. "An improved incandescence electric lamp." E. FRENOT and G. NOUVELLE. (Under International Convention.) Dated July 21st. The glass bulb is provided with a socket of insulating material soldered to the glass bulb, and which carries two pieces of good conducting metal, to which are attached platinum wires soldered to the ends of the filament in the usual manner. In the interior of the bulb, it may be at the upper part, a mirror is applied in such a manner as to form a parabolic reflector, by means of which the luminous intensity of the lamp is increased. 1 claim.

1,924. "An electric switch." G. S. GRIMSTON. Dated February 1st. On turning a spindle in the one direction (a stop preventing it from being turned in the opposite direction), a blade spring is bent into a curve so that its end becomes withdrawn from behind a spring pawl, whereupon the arm turns until it meets the stop, and the blade spring becomes engaged behind the second spring pawl. The arm being thus moved off the segmental plate, the circuit is opened. In order to close the circuit again, the spindle has to be turned back, bending the blade spring until its end escapes the second spring pawl, whereupon the arm moves back on to the segmental plate and the blade spring is again engaged behind the first pawl. A cover enclosing the mechanism is screwed or otherwise fixed on the base, the button or handle projecting through a hole in the cover. 1 claim.

5,654. "Improvements in dynamo electric machines." A. C. REIGNIER. Dated March 22nd. Claims:—1. In an arrangement of dynamo electric machine, the constitution of the ring by means of bimetallic plates, that is to say, plates formed of two metals, the one magnetic and the other a good conductor, and in the following order: The conducting metal, the magnetic metal, and the conducting metal, and being intimately in contact. 2. The arrangement of dynamo constructed as described with reference to the drawings.

7,264. "Improvements in electric arc lamps." H. T. HARRISON. Dated April 14th. Has reference to a simple and compact construction of electric arc lamps, in which a nearly closed magnetic field and a friction block connected to the cores of suitable coils are employed, the said block being caused to act at the required times upon pulleys over which pass cords that carry the carbon holders, and which are so mounted as to be capable of assuming different distances apart. 2 claims.

7,404. "Improvements in or relating to electric railways and railway cars." S. H. SHORT. Dated April 19th. Has reference to improvements in electric motor calls in which the propelling motor, both the field magnets, and the armature or armatures, are axially mounted with reference to a car axle, in such manner that the motor as a whole may have lateral or vertical transverse vibratory movement with reference to such car axle, without touching the latter, so that the shocks received by the driving wheels are not transmitted at all, or are only transmitted feebly to the motor. 14 claims.

8,493. "Improved telephone transmitter." R. WHITEHEAD and A. DOXEY. Dated May 5th. A ring of carbon, or other suitable material, is suspended by its inner edge resting on two carbon or other suitable supports or electrodes, each electrode being attached to the centre of a separate diaphragm. The two diaphragms are then placed parallel to each other, and separated by a ring of suitable thickness, forming a case, which encloses ring and electrodes, and permitting access of sound waves to the outside of each diaphragm only. 3 claims.

9,331. "Improvements in the mode of and apparatus for the transmission of currents through conduits for the propulsion electrically of railway cars and the like." J. W. GRANTLAND. Dated May 17th. Comprises in electric railway propulsion the mode of supplying electric currents to moving vehicles, which consists in electrifying the exterior surface of a conductor, dissipating moisture from the electrified surface thereof by passing a drying medium in contact with the interior surface of the conductor, and leading the current from the electrified surface of the conductor to the moving vehicles. Further comprises in electric railway propulsion the mode of transmitting electric currents to moving vehicles, which consists in electrifying the exterior surface of a conductor, passing a heating or drying medium in contact with the interior surface of the conductor, reheating said medium, and leading the current from the electrified surface of the conductor to the moving vehicles. Further comprises in electric railway propulsion the mode of preventing leakage from a subway electric main or conductor, which consists in electrifying the surface of the conductor, dissipating moisture from the electrified surface thereof by passing a drying medium through the conductor, and maintaining said medium in a heated condition. 20 claims.

11,592. "Means for operating ammeters and other electrical apparatus." C. K. MILLS. (A communication from H. M. Pilkington and R. S. White, both of America.) Dated June 21st. According to the invention said apparatus is operated, not by a single circuit in the usual manner, but by two or more circuits, the effect of the current in each circuit being added to that of the other circuits to accomplish the entire desired result, although in some cases the effect of the current in a single one of the circuits is complete in itself, but constitutes only a fraction of the entire operation which the apparatus is designed to perform. 6 claims.

11,948. "Improvements in electric fire alarms." H. CORTLAND. Dated June 27th. Has reference to an automatic electric alarm controlled by a thermostat in such manner that when an excessive temperature occurs an alarm will be sounded in the building, or at a central station, or both, and that if the increase in temperature continues a second alarm will be sounded. The inventor combines with a thermostat adapted to first open and then close a circuit as the temperature increases, circuits including alarms, and a clock mechanism controlling the circuits. 6 claims.

12,238. "Improvements in and apparatus for producing and utilising electric currents." B. SCHEITHAUER. Dated July 1st. Refers to apparatus in which two induction coils, by means of an automatic contact breaker and maker, alternately come into action, and both induction coils are connected with two separate secondary batteries, in such a manner that one battery current gives the primary current to one induction coil, whilst the other battery is charged by a portion of the induction current produced in such manner, and *vice versâ*. The superfluous portion of this induction current serves for the maintenance of the circuit service. 2 claims.

12,818. "Improvements in or connected with conduits for electric railways." J. E. EVANS-JACKSON. (Communicated from abroad by C. D. C. Huestis, of America.) Dated July 12th. Its objects are to provide an improved conduit which shall better prevent the entrance of foreign substances into it, which shall be more convenient in its construction and economical in use, and which shall provide for improved and complete drainage of any water which may enter the slot (from the surfaces) through which the supporting arm of the contact devices passes. 3 claims.

13,919. "Improvement in incandescent electric lamps." ELIHU THOMSON. Dated July 30th. Claims:—1. An incandescent electric lamp having an exhausted chamber formed with external screw threads for entering a socket, substantially as described, the lamp being provided with contacts on its base, which are insulated by the material of the lamp from the enclosing shell of the socket, and are adapted to connect with corresponding contacts in the said socket. 2. An incandescent lamp having its exhausted chamber provided with external screw threads adapted to enter the lamp socket, and a shade or shade-holder having a threaded opening adapted to engage with external screw threads on the lamp socket. 3. An adapter for incandescent lamps, consisting of a screw-threaded shell adapted to receive and hold the neck of the lamp, and provided with contacts adapted to complete the circuit between corresponding contacts on the lamp and in the socket. 4. The method of making an incandescent lamp which consists in sealing within the neck of the bulb a tube closed at its inner end, placing the neck in a screw-threaded mould and blowing the glass into the neck of the mould, whereby screw threads are formed upon the neck portion of the bulb.

13,996. "Improvements in electrical generators." W. HENRY. Dated August 2nd. Consists in the peculiar construction, arrangement, and combination of different parts, whereby dynamic electricity in any desired form of current is generated by means of statical induction. 9 claims.

1706

INDEX TO ADVERTISEMENTS.

The names of Advertisers, whose announcements are ordered for a series, are entered under any one Heading in this Index free of charge, but if repeated under other headings, 6d. per week is charged for each additional entry.

Accumulators. PAGE
Drake & Gorham 5
Electrical Power Storage Co. ... 14
Epstein Accumulator Co. ... 21
J. Stiff & Sons (Boxes only) ...
Arc Lamps.—Gwynne & Co. ...
International Electric Co. ... 13
Johnson & Phillips 1
Körting & Mathiesen ... ...
The Electrical Company *Sup.* 2
Waterhouse Electric Mfg. Co. ...
Asbestos.
United Asbestos Co. ... ...
Auctioneers and Valuers (Mechanical).
Wheatley Kirk, Price & Goulty *Sup.* 7
Batteries.
R. Aylmer (Leclanché) ... ...
W. H. Baughan & Co. ... *Sup.* 9
India-Rubber Co.... 22
Johnson & Phillips 1
Sharp & Kent (Weymersch) ...
Telegraph Mfg. Co. ... *Sup.* 1
Battery Jars.
J. Bourne & Son 19
J. Stiff & Sons ... ... *Sup.* 8
Bells.
Butzke & Co. 13
General Elec. Co., Ld. ... *Sup.* 6
Sheppard, Allarton & Madeley ...
Belting.—Webb & Son ... *Sup.* 11
Books.
Berly's Universal Elec. Directory 18
C. Griffin & Co. ... ... *Sup.* 7
Cabinet Work.
W. M. Foxcroft 3
Carbons.
H. & F. Chamberlain 6
Genl. Elec. Co., Ld. (G. Binswanger) *Sup.* 6
Gwynne & Co. ... ...
Johnson & Phillips 1
The Electrical Company *Sup.* 2
Castings.—Phosphor Bronze Co. ... 10
Chemicals.—G. Boor & Co.... ... 13
Dynamos.
Crompton & Co. ... ... *Sup.* 12
Gülcher Electric Light & P. Co. 19
Gwynne & Co. ... ...
J. H. Holmes & Co. ... *Sup.* 7
Johnson & Phillips 1
Laurence, Scott & Co. ... ...
Mather & Platt ... ... *Sup.* 2
Rosling & Matthews 19
Ernest Scott & Mountain ... 15
J. G. Statter & Co. 8
The Electrical Company *Sup.* 2
Wray Elec. Engineering Co. ... 3
Ebonite.
Harburg I. R. Comb Co. ... *Sup.* 7
D. Moseley & Sons ... ...
Electrical Engineers and Contractors.
Burbey, Williamson & Joseph *Sup.* 5
British Electric Light Co. ... 15
Brush Electrical Engineering Co. 12
Callender's Bitumen Tel. &c. Co. 7
Charlesworth, Hall & Co. ...
Clarke, Chapman & Co. 8
Crompton & Co. ... ... *Sup.* 12
Drake & Gorham 5
Electric Construction Company 9
Elliott Bros. ... ... *Sup.* 12
Gwynne & Co. ... ...
India-Rubber & Telegraph Works Co. 22
Johnson & Phillips 1
Laing, Wharton & Down ... 4
Laurence, Scott & Co. ... ...
Mather & Platt ... ... *Sup.* 2
Paterson & Cooper 21
Reid Bros. 10
Russell & Co. 12
Ernest Scott & Mountain ... 15

Electrical Engineers, &c.—*Cont.* PAGE
Siemens Bros. & Co. 16
Swinburne & Co. ... ...
Telegraph Mfg. Co. ... *Sup.* 1
The Electrical Company *Sup.* 2
Western Electric Company *Sup.* 12
Electric Light Fittings.
Burbey, Williamson & Joseph *Sup.* 5
Benham & Froud... 2
G. Braulik ... ... *Sup.* 10
Dorman & Smith 11
Electrical Accessories Co. ...
Faraday & Son 12
Genl. Elec. Co., Ld. (G. Binswanger) *Sup.* 6
A. P. Lundberg ... ...
Strode & Co. ... ...
The Paiste Switch ... ...
The Electrical Company *Sup.* 2
B. Verity & Sons ... ... *Sup.* 1
Walsall Electrical Co. 17
Woodhouse & Rawson United *Sup.* 9
Electricity Meters.
Jos. Edmondson 2
Engines for Electric Light.
G. E. Belliss & Co. ... *Sup.* 10
Browett, Lindley & Co. 6
Greenwood & Batley 21
Gwynne & Co. ... ...
Marshall, Sons & Co. 19
Premier Gas Engine ... ...
Ransomes, Sims & Jefferies ...
Stockport Gas Engine 9
Willans & Robinson ... *Sup.* 11
Fibre.
David Moseley & Sons ... ...
Fire Insurance.
Phœnix Office ... ... *Sup.* 3
Forgings.—R. Jenkins 8
Fuel Economiser.
E. Green & Son, Ltd. ... ...
Glass.
General Elec. Co. (G. Binswanger) *Sup.* 6
Incandescence Lamps.
Edison & Swan United E. L. Co. ...
The Electrical Co. ... *Sup.* 2
Zürich Incan. Lamp Co. ..
India-Rubber.
India-Rubber, G. P. & Tel. Wks. Co. 22
D. Moseley & Sons ... ...
Institution.
Durham College Science *Sup.* 8
Military & Engineering College *Sup.* 9
Owens College, Manchester *Sup.* 8
University College of N. Wales *Sup.* 8
Victoria University, Liverpool *Sup.* 8
Insulators, &c.
Bourne & Son 19
Price, Sons & Co.... 6
Stiff & Sons ... ...
Telegraph Mfg. Co. ... *Sup.* 1
Iron and Steel.—Turner Bros. ... 6
Ladders.
J. H. Heathman & Co. 8
Lubricants.
E. G. Cockrell & Co. ... ...
W. H. Willcox & Co. 3
Magnet Steel.—G. P. Wall ... 13
Manufacturing Electricians.
Dorman & Smith 11
Elliott Bros. ... ... *Sup.* 12
Gwynne & Co. ... ...
Hartmann & Braun 21
King, Mendham & Co. 12
Laurence, Scott & Co. ... ...
Mackey, Mackey & Co. ... ...
Mix & Genest 13
Nalder Bros. ... ...
Strode & Co. ... ...
Telegraph Mfg. Co. ... *Sup.* 1
The Electrical Company *Sup.* 2

Manufacturing Electricians.—*Cont.* PAGE
Walsall Electrical Company ... 17
James White 7
Woodhouse & Rawson United *Sup.* 9
Mica.
Canadian Elec. Insulations Co. ...
F. Wiggins & Sons 3
Motors.
Cuttriss, Wallis & Co. 12
Gülcher Electric Light & P. Co. 19
Gwynne & Co. ... ...
The Electrical Company *Sup.* 2
Patent Agents.—H. Gardner ... 8
J. G. Lorrain ... ... *Sup.* 8
Platinum.—Derby & Co. ... *Sup.* 8
Poles.
Johnson & Phillips (Wood and Iron) 1
Porcelain Appliances.
Dorman & Smith 11
Genl. Elec. Co., Ld. (G. Binswanger) *Sup.* 6
Porous Cells.
J. Stiff & Sons ... ...
Pulleys, Shafting, &c.
J. Bagshaw & Sons ... *Sup.* 11
Gwynne & Co. ... ...
Railway Signals.
Saxby & Farmer 12
Screws.
Automatic Standard Screw Co. 15
Davis & Timmins 20
Shutters, Hoists, &c.
Payne-Gallwey & Co. .. *Sup.* 9
Stabilit.—The Electrical Co. *Sup.* 2
Stampings.—R. Jenkins 8
Telegraph Engineers.
Johnson & Phillips 1
Siemens Bros. & Co. 16
Telegraph Mfg. Co. ... *Sup.* 1
Telephones.
O. Berend & Co. ... ...
Collier-Marr Telephone, &c., Co. 12
Gent & Co. 7
Ch. Mildé & Co. 6
G. A. Nussbaum ... ... *Sup.* 11
Western Electric Co. ... *Sup.* 12
Tenders. ... ... *Sup.* 8
Tools, &c.
C. Churchill & Co. 10
H. Milnes ... ...
Turbines.
Gilbert Gilkes & Co. ... *Sup.* 11
Gwynne & Co. ... ...
S. Howes ... ... *Sup.* 2
Vulcanite.
Harburg I. R. Comb Co.... *Sup.* 7
Water Purifiers.
Stanhope Water Engineering Co.
Wire (Covered).
Felten & Guilleaume ... ...
Fowler-Waring Cables Co. ...
W. T. Glover & Co. 2
W. T. Henley's Telg. Works Co.
London Electric Wire Co. ... 5
W. Rickard ... ...
Telegraph Mfg. Co. ... *Sup.* 1
The Electrical Co. ... *Sup.* 2
United Electric Wire Co. ... 6
Wire (Uncovered).
Davis & Timmins 20
Phosphor Bronze Co 10
Ramsden, Camm & Co. 15
F. Smith & Co. 3
Wire Covering Machinery.
Johnson & Phillips ... *Sup.* 9
Wood Casings.
Genl. Elec. Co., Ld. (G. Binswanger) *Sup.* 6
J. F. & G. Harris 6
Vigers Bros. ... ... *Sup.* 8
Wood Carving Co. ... *Sup.* 3

MISCELLANEOUS ADVERTISEMENTS *relating to Situations, Articles for Sale and Wanted, &c., &c., appear on Sup.* 7 *(middle of paper).*

CROMPTON & CO., LIMITED, SEE SUP. 12.

FARADAY & SON'S

SPECIALITIES IN ELECTRIC LIGHTING.

High-Class Fittings. Original Designs.

3, BERNERS STREET, W.

214

ELECTRICAL INTERLOCKING.

GOLD MEDAL, CRYSTAL PALACE, 1892.

The Board of Trade have again and again urged the necessity of combining the "Lock" and "Block" systems by actual connection between the Telegraph Instruments and Locking Levers, to effect "inter-dependent working." This great improvement, together with Supplementary Automatic Train Action, has been reliably accomplished and brought into practical use on several lines by Messrs. SAXBY & FARMER, under protection of various Patents granted or assigned to them. *Diploma of Honour (the Highest Award), Edinburgh, 1890.* For Particulars, Plans, and Estimates, apply to

SAXBY & FARMER, Ltd., Railway Signal Contractors Canterbury Road, KILBURN, LONDON, N.W.

Manufacturers of Railway Signals, Cabins, Interlocking Levers, Block Instruments, and Signal Work of every description, Electrical and Mechanical. 1443

IT IS GENERALLY ACKNOWLEDGED that the Street Lighting of the Western and Central Divisions of the City is

THE BEST ARC LIGHTING IN LONDON.

For PRICES of DIRECT and ALTERNATE CURRENT ARC LAMPS for Indoor and Outdoor use,

Apply to the

BRUSH ELECTRICAL ENGINEERING COMPANY, LTD.

49, QUEEN VICTORIA ST., LONDON, E.C.

573

K.M.B. PORTABLE TESTING SET.

Specially designed for testing insulation resistances by the direct deflection method. Fitted with 4-inch silvered dial, coil of 10,000 ohms, and $\frac{1}{10}$ shunts and contact key. Full instructions in cover.

Price £6 6s. 0d.

KING, MENDHAM & CO.,

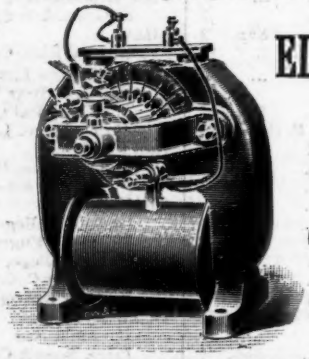
WESTERN ELECTRICAL WORKS, BRISTOL,

London Agent: W. B. ALLISON, 12, FENCHURCH ST., E.C.

LARGE ILLUSTRATED CATALOGUE, POST FREE 6D. 3798

CUTTRISS, WALLIS & CO., LTD.

Electrical Engineers & Manufacturers.



ELECTRO-MOTORS

From $\frac{1}{10}$ to 50 H.P.

DYNAMOS

For all purposes.

COMPLETE PLANT FOR ELECTRIC LIGHT AND TRANSMISSION OF POWER.

Contractors for the erection of Bells, Telephones, &c.

3695

ELMWOOD ELECTRICAL WORKS & 1, BOND PLACE, LEEDS

COUNTRY HOUSES

FITTED WITH THE

ELECTRIC LIGHT AND ENGINES,

GAS OR STEAM.

RUSSELL & CO.

Among our other Specialties are-

SHIP LIGHTING PLANT, BOILERS, ENGINES,

COMPLETE PLANTS FOR SHIPMENT ABROAD.

Offices :—11, QUEEN VICTORIA STREET, LONDON, E.C. Telegrams:—"OUKETI, LONDON." 6442